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For arrangement of subjects and authors see page v.

MORRIS'S

HUMAN ANATOMY

A COMPLETE SYSTEMATIC TREATISE BY ENGLISH AND AMERICAN AUTHORS

EDITED BY

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FOURTH EDITION, REVISED AND ENLARGED

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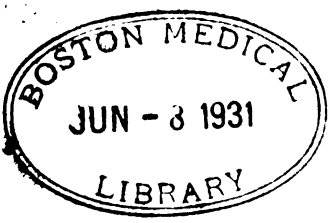

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ARRANGEMENT OF SUBJECTS AND AUTHORS.

The names of those who originally wrote articles and those who revised and wrote for previous editions have been retained in the following list of contents, in order that due credit should be given them for the work done and for their share in the great success which Morris's "Anatomy" has achieved throughout England and America.

MORPHOGENESIS. (The Development of Structure.) By J. PLAYFAIR McMURRICH, A.M., PH.D., Professor of Anatomy, University of Michigan; Member Association of American Anatomists; Member of Advisory Board, Wistar Institute of Anatomy; Member of Editorial Board of "American Journal of Anatomy;" Author of "The Development of the Human Body."

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NERVOUS SYSTEM. Revised and largely rewritten by IRVING HARDESTY, A.B., PH.D., Assistant Professor of Anatomy, University of California; Member Association of American Anatomists. This section was originally written by the late H. St. John Brooks, M.D., formerly Chief Demonstrator of Anatomy, University of Dublin, and revised for the Second and Third Editions by Arthur Robinson, M.D., Professor of Anatomy, University of Birmingham.

ORGANS OF SPECIAL SENSE. Eye.—By R. MARCUS GUNN, F.R.C.S., Senior Surgeon, Royal London Ophthalmic Hospital (Moorfields); Surgeon to the Western Ophthalmic Hospital and to the National Hospital for the Paralysed and Epileptic. Ear, Nose, Tongue.—By ABRAM T. KERR, B.S., M.D., Professor of Anatomy, Cornell University; Member Association of American Anatomists. The sections on Ear, Nose, Tongue in previous editions were written by the late Arthur Hensman, F.R.C.S., and revised by Arthur Robinson, M.D., Professor of Anatomy, University of Birmingham.

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THE DUCTLESS GLANDS, INCLUDING THE THYREOID GLAND. By G. CARL HUBER, M.D., Professor of Histology and Embryology in the University of Michigan; Secretary Association of American Anatomists.

THE SKIN AND MAMMARY GLAND. By ABRAM T. KERR, B.S., M.D., Professor of Anatomy, Cornell University; Member Association of American Anatomists, etc. This article was originally written by the late William Anderson, F.R.C.S., formerly Vice-President Anatomical Society of Great Britain.

SURGICAL AND TOPOGRAPHICAL ANATOMY. By W. H. A. JACOBSON, F.R.C.S., Consulting Surgeon to Guy's Hospital; formerly Lecturer on Anatomy, Guy's Hospital Medical School; Author of "The Operations of Surgery," etc.

ABSTRACT OF PUBLISHERS' NOTE

AS PRINTED IN PART I

The very favorable reception accorded the previous editions of this work in America suggested the desirability of making the present (fourth) edition international in its character, by placing it largely in the hands of an American editor and by securing the services of American Anatomists in the revision or rewriting of certain of the sections.

The entire work has undergone a complete revision, and some sections have been entirely rewritten and, in several instances, considerably enlarged; the text has been brought thoroughly up to date by the inclusion of the results of recent investigations, and represents, accurately, the present state of Anatomy. Many illustrations which appeared in previous editions have been omitted, a large number of new figures have been made from specially prepared drawings, and pictures from other books have been included where they served the desired purpose.

Special attention should be directed to the use throughout the volume of the nomenclature adopted by the German Anatomical Society and generally known as the Basle nomenclature, or BNA. In employing this nomenclature the editors have been guided by a desire to assist in the unification of anatomical terminology, seeing in such unification an earnest of the thorough internationalization of the science of anatomy and more rapid progress in its development. The modifications of the accepted English nomenclature necessitated by the adoption of the BNA are comparatively few, and where they are radical, the more familiar terms have been added in parentheses. Whilst this is the first text-book of Anatomy in English to adopt the BNA in its entirety, there are a number of books and papers on Embryology, Histology, and Biology in which it is used; its general adoption in the future, it may be confidently expected, will be assured. In this connection, reference should be made to a new book by Prof. Llewellys F. Barker, of Johns Hopkins University, in which a complete list of the terms used in the BNA is given and in which the object, system, and practicability of the nomenclature are explained.

Each author is alone responsible for the subject-matter of the article following his name. Care has been exercised on the part of the editors, however, to make the whole uniform, complete, and systematic.

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SURGICAL AND TOPOGRAPHICAL ANATOMY

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The mode of describing illustrations which has been carried out as far as practicable consists in printing the descriptions in different types at the end of the pointers. Thus, the **muscles, fascia, and ligaments** are in one kind of type; *arteries, veins, and lymphatics* in another; BONES AND SPECIAL ORGANS in a third; *NERVE STRUCTURES* in a fourth.

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SECTION XIII

ON SURGICAL

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TOPOGRAPHICAL ANATOMY

By W. H. A. JACOBSON, M.Ch.Oxon.

CONSULTING SURGEON, GUY'S HOSPITAL, LONDON

SUPERFICIAL ANATOMY OF THE HEAD AND NECK

THE CRANIUM AND SCALP

Bony landmarks.—These should be studied with the aid of a skull, as well as on the living subject. Beginning in front is the **nasion,** a depression at the root of the nose, and immediately above it, the **glabella,** a slight prominence joining the two supraciliary ridges. These points mark the remains of the frontal suture, and the junction of the frontal, nasal, and superior maxillary bones and one of the sites of a meningocele. In the middle line, behind, is the external occipital protuberance, or **inion,** the thickest part of the vault, and corresponding internally with the meeting-point of six sinuses. A line joining the inion and glabella corresponds to the sagittal, and occasionally the frontal, suture, the falx cerebri, the superior sagittal sinus, widening as it runs backwards, and the longitudinal fissure of the brain. From the inion the superior curved lines pass out towards the upper and back part of the base of the mastoid processes, and indicate the first or so-called horizontal part of the transverse (lateral) sinus. This vessel usually presents a varying curve upwards and runs in the tentorium. The second or sigmoid portion turns downwards on the inner surface of the mastoid, then forwards, and lastly downwards again to the jugular foramen, thus describing the double curve from which this part takes its name. In the jugular foramen the vessel occupies the posterior compartment; its junction with the internal jugular is dilated and forms the bulb. A line curved downwards and forwards from the upper and back part of the base of the mastoid, reaching two-thirds of the way down towards the apex, will indicate the second part of the sinus. The spot where it finally curves inwards to the bulb would be about 1·8 cm. (¾ in.) below and behind the meatus. The two portions of the transverse sinus meet at the asterion externally; at the entry of the superior petrosal sinus internally. The right transverse sinus, the larger, is formed mainly by the superior sagittal sinus, and, therefore, receives blood chiefly from the cortex of the brain; the left, arising in the straight sinus, drains the interior of the brain and the basal ganglia. Each lateral sinus receives blood from the temporal lobe, the cerebellum, diploë, mastoid antrum, and two emissary veins, the mastoid and posterior condylar.

About 6·2 cm. (2½ in.) above the external occipital protuberance is the **lambda,** or meeting of the sagittal and lambdoidal sutures (posterior fontanelle, small and triradiate in shape). It is useful to remember, as guides on the scalp to the above

two important points, that the lambda is on a level with the supraciliary ridges, and the external occipital protuberance on one with the zygomatic arches.

Below the external occipital protuberance, between it and the foramen magnum, an **occipital,** the commonest form of cranial **meningoceles,** makes its appearance. It comes through the median fissure in the cartilaginous part of the squamous portion of the bone. The point of junction of the occipital, parietal, and mastoid bones, the **asterion,** is placed about 3·7 cm. (1½ in.) behind and 1·2 cm. (½ in.) above the centre of the auditory meatus (fig. 927). It indicates the site of the posterior lateral fontanelle, and just below it, the superior curved line terminates. The **bregma,** or junction of the coronal, sagittal, and, in early life, the frontal suture (anterior fontanelle, large and lozenge-shaped), lies just in front of the centre of a line drawn transversely over the cranial vault from one pre-auricular point to the other (fig. 933). The **pterion,** or junction of the frontal and sphenoid in front, parietal and squamous bones behind, lies in the temporal fossa, 3·7 to 5 cm. (1½ to 2 in.) behind the external angular process of the frontal, and about the same distance above the zygoma (fig. 926). This spot also gives the position of the trunk and the anterior and larger division of the middle meningeal artery (fig. 933), the Sylvian point and divergence of the limbs of the lateral (Sylvian) fissure, the insula (island of Reil), and middle cerebral artery. It, further, corresponds to the anterior lateral fontanelle. On the side of the skull the **zygomatic arch,** the **temporal ridge,** and **external auditory meatus** need attention. That important landmark, the **zygomatic arch,** wide in front where it is formed by the zygomatic (malar), narrowing behind where it joins the temporal, gives off here three roots, the most anterior marked by the eminentia articularis, in front of the mandibular (glenoid) fossa, the middle behind this joint, while the posterior curves upwards and backwards to be continuous with the temporal ridge. Within the zygomatic arch lie **two fossæ** separated by the infra-temporal (pterygoid) ridge: above is the **temporal,** with the muscle and deep temporal vessels and nerves; below is the **infra-temporal** or **zygomatic** fossa, with the lower part of the temporal muscle, the two pterygoids, the internal maxillary vessels, and the mandibular division of the fifth. To the upper border of the zygomatic arch is attached the temporal fascia, to its lower, the masseter. Its upper border marks the level of the lower lateral margin of the cerebral hemisphere. A point corresponding to the middle root of the zygoma, immediately in front of the tragus, and on a level with the upper border of the bony meatus, is called the **pre-auricular point.** Here the superficial temporal vessels and the auriculo-temporal nerve cross the zygoma, and a patient's pulse may be taken by the anæsthetist. The importance of this point in cranio-cerebral topography is given at p. 1270. The lower end of the central (Rolandic) fissure lies 5 cm. (2 in.) vertically above this point. The **temporal ridge,** giving origin to the temporal fascia, starts from the external angular process of the frontal, and becoming less distinct, curves upwards and backwards over the lower part of that bone, crosses the coronal suture, traverses the parietal bone, curving downwards and backwards to its posterior inferior angle. Here it passes on to the temporal, and passing forwards over the external auditory meatus, is continuous with the posterior root of the zygoma. Below the root of the zygoma will be felt the temporo-mandibular joint, and when the mouth is opened, the condyle will be felt to glide forwards on the eminentia articularis, leaving a well-marked depression behind.

The **external auditory meatus,** measured from its opening on the concha to the membrane, is about 2·5 cm. (1 in.) in length; if from the tragus, 3·7 cm. (1½ in.). Its long axis is directed inwards and a little forwards with a slight convex curve upwards, most marked in its centre. Between the summit of this curve and the membrane is a slight recess in which foreign bodies may lodge. The lumen is widest at its commencement, narrowest internally. To bring the cartilaginous portion in line with the bony, the pinna should be drawn well upwards and backwards. In the bony portion the skin and periosteum are intimately blended, thus accounting for the readiness with which necrosis occurs. The sensibility of the meatus is explained by the two branches sent by the auriculo-temporal nerve. The fact that the deeper part is supplied by the auricular branch of the vagus explains the vomiting and cough occasionally met with in affections of the meatus.

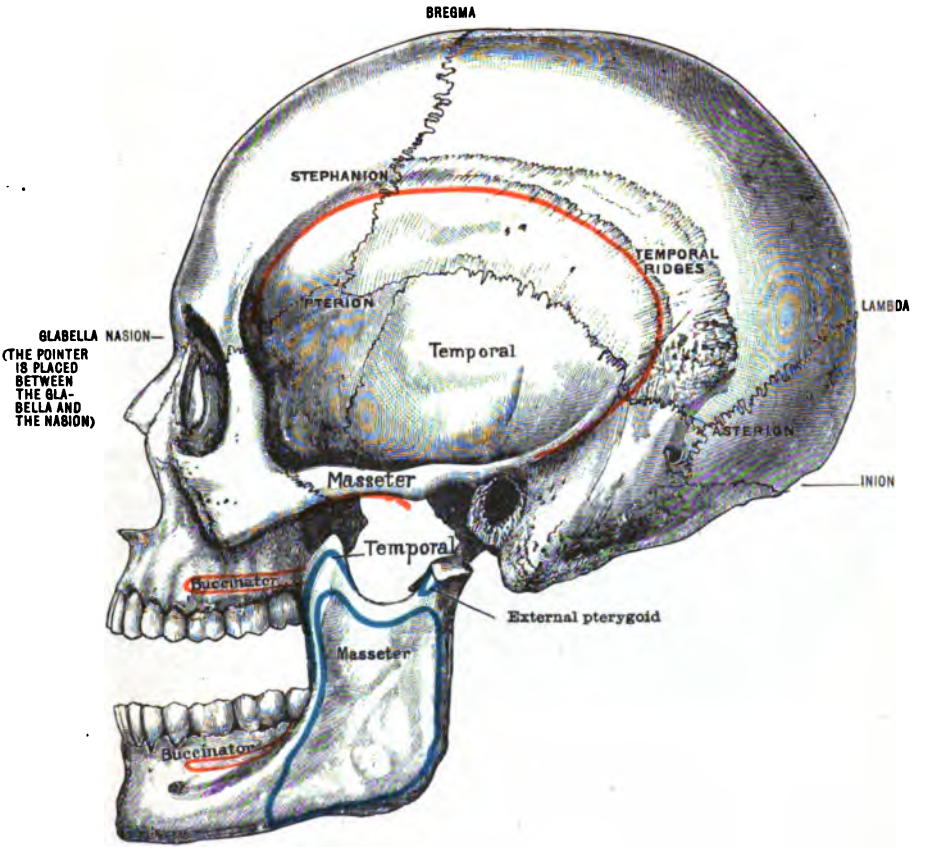
The anterior inferior angle of the parietal bone, and its great importance as a landmark, have already been noted. The posterior inferior angle of this bone (grooved by the lateral sinus) lies a little above and behind the base of the mastoid, on a level

with the roots of the zygoma (fig. 927). Just below and in front of the tip of the mastoid the transverse process of the atlas can be made out in a spare subject.

The average thickness of the adult skull-cap is about 5 mm. ($\frac{1}{5}$ in.). (Holden.) The thickest part is at the external occipital protuberance, where the bone is often 1·8 cm. ($\frac{3}{4}$ in.) in thickness. The thinnest part of the skull vault is over the temporal part of the squamous. The extreme fragility of the skull here is partly compensated for by the thickness of the soft parts; these two facts are always to be remembered in the diagnosis of a fracture of the skull here, after a slight injury. Other weak spots are the inner wall of the orbit, the cerebellar fossæ, and that part of the middle fossa corresponding to the glenoid cavity.

In front, the circumference of the bony orbit can be traced in its whole extent. The supraorbital notch lies at the junction of the inner and middle thirds of the supraorbital arch. When this notch is a complete foramen, its detection is much

FIG. 927.—THE SKULL.



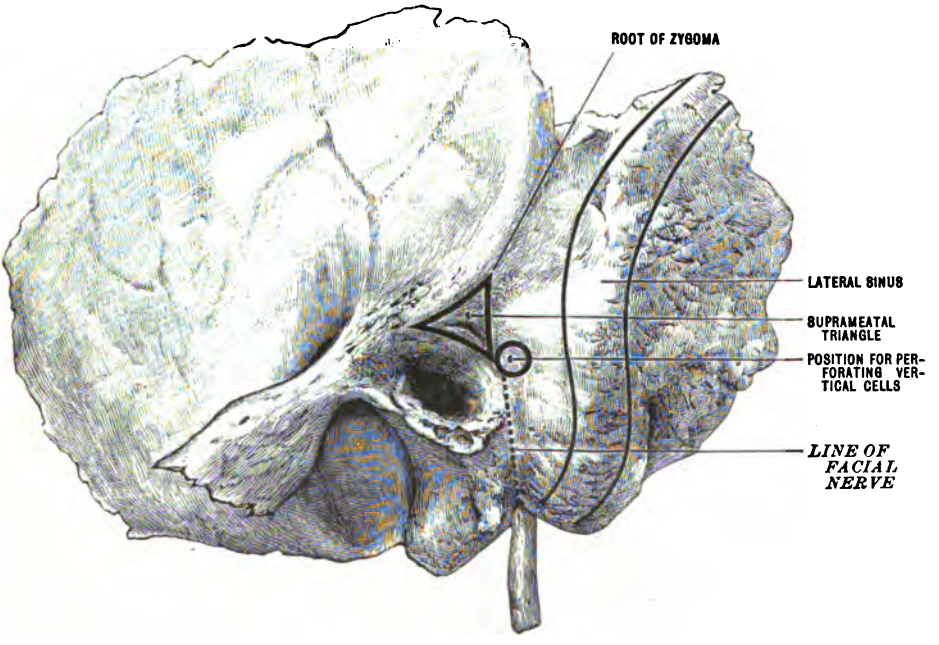
less easy. To its inner side the supratrochlear nerve and frontal artery cross the supraorbital margin; like the supraorbital, this nerve and vessel lie, at first, in close relation with the periosteum. The frontal artery is one of the chief blood-supplies to flaps taken from the forehead. Owing to the paper-like thinness of the bones on the inner wall of the orbit, e.g., lachrymal, ethmoid, and body of sphenoid, and the mobility of the skin, injuries which are possibly penetrating ones, as from a slate-pencil, ferrule, etc., are always to be looked upon with suspicion. After a period of latency of symptoms, infection of the membranes and frontal abscess have often followed. Above the supraorbital arch is the supraciliary arch, and higher still the frontal eminence. From the supraorbital notch, a line drawn downwards and slightly outwards, so as to run between the two bicuspid teeth in each jaw, passes over the infraorbital and mental foramina. (Holden.) The infraorbital foramen lies a full 6 mm. ($\frac{1}{4}$ in.) below the margin of the orbit. The mental foramen in the

adult is placed midway between the upper and lower margins of the jaw, and is a little over a quarter of an inch below the *cul-de-sac* of mucous membrane between the lower lip and the jaw.' (Treves.)

The bony sinuses.—The frontal.—The development of these by the twentieth or twenty-fifth year may render a fracture here much less grave in the adult than would otherwise be the case, the inner table, if now separated from the outer, protecting the brain. Mr. Hilton showed that the absence of any external prominence here does not necessarily imply the absence of a sinus, as this may be formed by retrocession of the internal table. In old people these sinuses may enlarge by the inner table following the shrinking brain. Again, prominence of the supraciliary and frontal eminences does not necessarily point to the existence of a sinus at all, being due merely to a heaping up of bone.

When well developed, the frontal sinuses may reach 5 cm. (2 in.) upwards and 3·7 cm. (1½ in.) outwards, occupying the greater part of the vertical portion of the frontal bone. When very small, they scarcely extend above the nasal process. Even when present, they are rarely symmetrical. The average dimensions of an

FIG. 928.—TEMPORAL BONE, SHOWING SUPRAMEATAL TRIANGLE. (Barr.)
The lower part of the lateral sinus is here placed too far back to be relied upon with constant accuracy.



adult frontal sinus are 3·7 cm. (1½ in.) in height, 2·5 cm. (1 in.) in breadth, and 1·8 cm. (¾ in.) in depth. (Logan Turner.) The sinuses are separated by a septum. The posterior wall is very thin. Each sinus narrows downwards into the infundibulum. This is 'deeply placed, at the back of the cavity, behind the frontal (nasal) process of the maxilla and near the inner wall of the orbit. Its termination in the middle meatus is about on a level with the palpebral fissure.' (Thane and Godlee.) Its direction is backwards.

The communication of these sinuses with the nose accounts for the frontal headache, the persistence of polypi and ozæna, and the fact that a patient with a compound fracture opening up the sinuses can blow out a flame held close by.

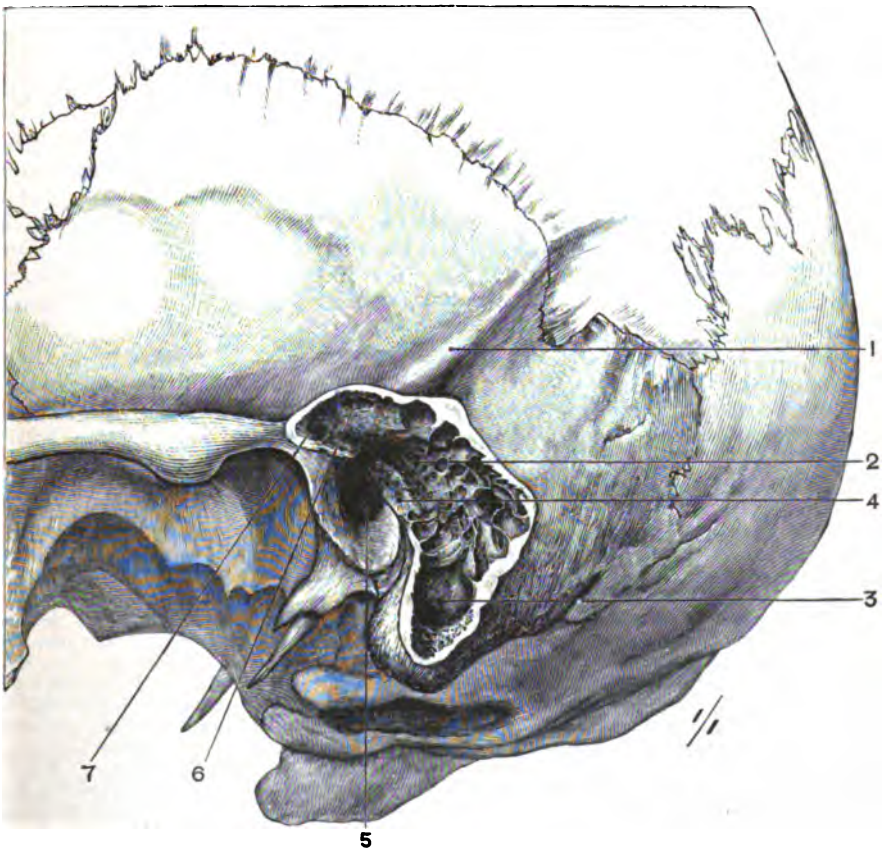
To open the frontal sinus, while the incision which leaves the least scar is one along the shaved eyebrow, superficial externally so to avoid the supraorbital nerve and vessels, running a little downwards at the inner end, it is always to be remembered that, where the sinuses are little developed, this or a median incision may open the cranial cavity. To avoid this complication the sinus should always be opened at a spot vertically above the inner canthus.

The **mastoid** cells are arranged in two groups, of the utmost importance in that frequent and fatal disease, inflammation of the middle ear:—(A) The **upper,** or **'antrum,'** present both in early and late life, horizontal in direction, closely adjacent to and communicating with the tympanum. (B) The **lower,** or **vertical.** This group is not developed in early life.

A. **Mastoid antrum** (fig. 929).—This is a small chamber lying behind the tympanum, into the upper and back part of which (tympanic attic) it opens. Its size varies, especially with age. Almost as large at birth, it reaches its maximum (that of a pea) about the third or fourth year. After this its size usually diminishes somewhat, owing to the development of the encroaching bone around it. Its **roof,** the

FIG. 929.—THE MASTOID ANTRUM AND CELLS. (Jacobson and Steward.)

1. Posterior root of zygoma forming the supramastoid or suprameatal crest and upper part of Macewen's triangle. 2. Antrum, and in front of it, the attic. 3. Vertical cells of the mastoid. 4. Ridge on the inner wall of the tympanum, caused by the facial canal. 5. Fenestræ on inner wall of tympanum, indicated in shadow. 6. A deficiency present in the tegmen tympani, enlarged with a small osteotrite to emphasise the thinness of the roof of the antrum and tympanum. 7. Cells extending, in this case, even into the root of the zygoma.



tegmen antri, is merely the backward continuation of the tegmen tympani. The level of this is indicated by the posterior root of the zygoma. 'The level of the floor of the adult skull at the tegmen antri is, on an average, less than one-fourth of an inch above the roof of the external osseous meatus; in children and adolescents, from one-sixteenth to one-eighth of an inch.' (Macewen.) In early life, when the bony landmarks, e. g. the suprameatal crest (fig. 928), are little marked, the level of the upper margin of the bony meatus will be the safest guide to avoid opening the middle fossa.

The **outer wall** of the antrum is formed by a plate descending from the squamous bone. This is very thin in early life, but as it developes by deposit from the peri-

osteum, the depth of the antrum from the surface increases. Macewen gives the average of the depth as varying from one-eighth to three-fourths of an inch. The thinness of the outer wall in early life is of practical importance. It allows of suppuration making its way externally—subperiosteal mastoid abscess. This will be facilitated by any delay in the closure of the petro- and masto-squamosal sutures, by which this thin plate blends with the rest of the temporal bone. Further, by the path of veins running through these sutures or their remnants, infection may reach such sinuses as the inferior petrosal. Through the **floor,** the antrum communicates with the lower or vertical cells of the mastoid. This floor is on a lower level than the opening into the tympanum, and thus drainage of an infected antrum is difficult, fluid finding its way more readily into the lower cells. **Behind** the mastoid antrum and cells is the bend of the sigmoid part of the transverse (lateral) sinus, with its short descending portion (fig. 928). The average distance of the sinus from the superior meatal triangle is 1 cm. ($\frac{2}{5}$ in.). It may be further back; on the other hand, it may come within 2 mm. ($\frac{1}{12}$ in.) from the meatus, and even overlap the outer wall of the antrum. Its surface-marking has been given at p. 1259.

The exact position of the antrum, a little above and behind the external auditory meatus, is represented by Macewen's 'suprameatal triangle.' This is a triangle bounded by the posterior root of the zygoma above, the upper and posterior segment of the bony external meatus below, and an imaginary line joining the above boundaries (fig. 928). 'Roughly speaking, if the orifice of the external osseous meatus be bisected horizontally, the upper half would be on the level of the mastoid antrum. If this segment be again bisected vertically, its posterior half would again correspond to the junction of the antrum and middle ear, and immediately behind this lies the suprameatal fossa.' (Macewen.) When opening the antrum through this triangle, the operator should work forwards and inwards, so as to avoid the sigmoid sinus (fig. 928); while, to avoid the facial nerve (fig. 928), he should hug the root of the zygoma and the upper part of the bony meatus as closely as possible. The level of the base of the brain will be a few lines above the posterior root of the zygoma (fig. 931) and about 6 mm. ($\frac{1}{4}$ in.) above the roof of the bony meatus. (Macewen.)

B. **The lower or vertical cells of the mastoid** are developed later than is the antrum, and vary much in their contents. The condition of the mastoid cells varies very widely. They may be numerous (fig. 929) or few. In the latter case they are replaced by diploë, or by bone which is unusually dense, without necessarily any pathological change. Hence mastoids have been classified as pneumatic, diploëtic, or sclerosed.

As part of the surgical anatomy of this most important region, the different paths by which infection of the tympanum and antrum may travel should be glanced at. The most important are:—(1) **Upwards:** either by advancing caries or by infection of veins going to the superior petrosal sinus, or through the tegmina to the membranes; an abscess in the overlying temporal lobe, usually the middle and back part. (2) **Backwards:** the transverse (lateral) sinus and cerebellum (abscess of the front and outer part of the lateral lobe) are reached in the same ways as those given above, the mastoid vein being the one chiefly affected here. Macewen has shown that the bony wall of the sinus, like those of the tegmina and the aqueduct of Fallopius, may be naturally imperfect. (3) **Downwards:** where the vertical cells are well developed (fig. 929) mischief may reach the digastric fossa and cause deep-seated inflammation beneath the sterno-mastoid. (4) **Outwards:** the explanation of this, in early life, has been given above. (5) **Inwards:** the facial nerve, or by the fenestra ovalis; the labyrinth is now in danger. When the internal ear and auditory nerve are affected, infection finds another path to the cerebellar fossa.

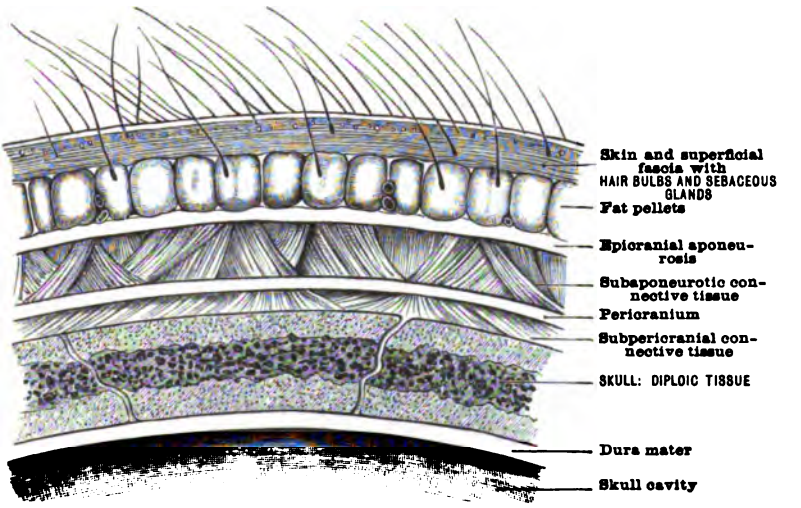
The **sphenoidal sinuses** are less important surgically, but these points should be remembered:—(1) Fracture through them may lead to bleeding from the nose, which is thus brought into communication with the middle fossa; (2) the communication of their mucous membrane with that of the nose may explain the inveteracy of certain cases of polypi and ozæna; (3) here and in the frontal sinuses very dense exostoses are sometimes formed. Before any operative attack on these sinuses is undertaken, their most important relations should be remembered. Thus **above** are the olfactory and optic nerves, the pituitary body, and front of the pons. **Externally** lie the cavernous sinus and superior orbital (sphenoidal) fissure. **Below** is the roof of the nose.

The scalp.—The importance of the **scalp** is best seen from an examination of its **layers** (fig. 930). These are—(1) **skin;** (2) **subcutaneous fat** and **fibrous tissue;** (3) the **epicranius** (occipito-frontalis) and **aponeurosis;** (4) the **sub-aponeurotic layer** of connective tissue; (5) the **pericranium.**

The first three layers are connected and move together. (1) The union of the **skin** and its density are to enable it to meet pressure, and also to prevent it rucking

into folds. Furthermore, they account for the extreme pain of inflammation here, e. g., in erysipelas, and the difficulty of raising a blister on the scalp. The presence of **hairs** and sebaceous glands is of much more importance than appears at first. Thus the rooting of the former is so firm that in the case of young women the whole scalp may be torn off by machinery. The **sebaceous glands** have also grave importance. If in removing cysts the aponeurosis beneath is pricked or the wound becomes foul, fatal suppuration in the 'dangerous area' beneath may follow. (2) The **subcutaneous fat** is arranged much as in the palm, viz., tough fatty pellets are enclosed in fibrous partitions, dipping from the skin to the third layer, and thus tying the three layers together. (3) The **epicranius (occipito-frontalis) and its aponeurosis** have been fully described elsewhere (p. 332). (4) The **sub-aponeurotic layer** of connective tissue. The characters of this layer are quite opposed to those of the layer of connective tissue above the aponeurosis. It is loose, delicate, and fatless. (5) **Pericranium.** This differs from periosteum elsewhere in that—(*a*) it gives little nourishment to the bone beneath: thus if it be stripped off and no infection follow, the resulting necrosis is slight; (*b*) when necrosis has taken place, any pericranium left has little restorative power. In early life it is in especial association with the dura, fusing with it at the fontanelles, and along the sutures, by the intersutural membrane. From these result the free mobility of the scalp, the fact that it can be torn

FIG. 930.—SECTION THROUGH THE SCALP, SKULL, AND DURA MATER. (Tillaux.)



away, and (most important of all) the facility with which inflammatory products can spread in the 'dangerous layer.' The perils of infection pent up here are extreme, viz., sloughing of the scalp, or necrosis of the bones, blood-poisoning, and meningitis, from mischief travelling along the emissary and diploic veins (fig. 930). The continuity of the different scalp layers by bands of connective tissue passing from the skin to the epicranius (occipito-frontalis), and thence along vessels, emissary and others, into the venous sinuses, or by the diploic veins within the skull, will account for scalp inflammation reaching the meninges.

Of the **vessels of the scalp,** the arteries, arising, in the anterior region, from the internal, in the posterior, from the external, carotid, are peculiar in their position. Thus they lie superficial to the deep fascia, which is here represented by the aponeurosis (fig. 930). From this position arises the fact that a large flap of scalp may be separated without perishing, as it carries its own blood-vessels. From the density of the layer in which the vessels run they cannot retract and are difficult to seize, hæmorrhage thus being free. Finally, from their position over closely adjacent bone, ill-applied pressure may easily lead to sloughing. A practical point with regard to the veins is given below. The lymphatics from the front of the scalp drain into the preauricular (p. 709), those behind into the posterior auricular and occipital nodes. The nerves are derived from all three divisions of the fifth, from the

facial, and also from three branches from the second and third cervical. The supply from the fifth explains the neuralgia in acute iritis, glaucoma, and herpes frontalis.

The emissary veins.—These are communications between the sinuses within, and the veins outside, the cranium. Most of them are temporary, corresponding to the chief period of growth of the brain. Thus in early life, when the development of the brain has to be very rapid, owing to the approaching closure of its case, a free escape of blood is most essential, especially in children, with their sudden explosions of laughter and passionate crying.

1. Vein through the foramen cæcum, between the anterior extremity of the superior sagittal sinus and the nasal mucous membrane. The value of this temporary outlet is well seen in the timely profuse epistaxis of children. Other more permanent communications between the skull cavity and nasal mucous membrane pass through the ethmoid foramina. The fact that the nasal mucous membrane is loose and ill-supported on the nasal conchæ (turbinated bones) allows its vessels to give way readily, and thus forms a salutary safeguard to the brain, warding off many an attack of apoplexy. 2. Vein through the mastoid foramen, between the transverse (lateral) sinus and the posterior auricular and occipital veins. This is the largest, the most constant, and the most superficial of the emissary veins. Hence the old rule of applying blisters or leeches over it in cerebral congestion. 3. Vein through the posterior superior angle of the parietal between the superior sagittal sinus and the veins of the scalp. 4. Vein through the condyloid foramen between the transverse (lateral) sinus and the deep veins of the neck. 5. Vein through the hypoglossal canal between the occipital sinus and the deep veins of the neck. 6. Ophthalmic veins communicating with the cavernous sinus and the angular vein. These veins may be the source of fatal blood-poisoning, by conveying out of reach septic material, in acute periostitis of the orbit, or in osteitis, of dental origin, of the jaws. 7. Minute veins through the foramen ovale between the cavernous sinus and the pharyngeal and pterygoid veins. 8. Communications between the frontal diploic and supraorbital veins, between the anterior temporal diploic and deep temporal veins, and between the posterior temporal and occipital diploic veins and the lateral sinus. In addition to the veins specially mentioned, the scalp and sinuses communicate by numerous diploic veins, by those in the inter-sutural membrane, and through sutures before their obliteration, as already explained.

The gravity of these emissary veins and their free communications with others are shown by the readiness with which they become the seat of thrombosis, and thus of blood-poisoning, in cranial injuries, erysipelas, infected wounds of the scalp, and necrosis of the skull.

Structure of cranium.—Two layers and intervening **cancellous tissue.** Each layer has special properties. The **outer** gives thickness, smoothness, and uniformity, and, above all, elasticity. The **inner** is whiter, thinner, less regular—e.g. the depressions for vessels, Pacchionian bodies, dura mater, and brain. Its chief characteristics are its fragility (vitreous) and absolute inelasticity. The **diploë,** formed by absorption after the skull has attained a certain thickness, reduces the weight of the skull without proportionately reducing its strength, and provides a material which will prevent the transmission of vibrations.

Results of the above varying elasticity.—A blow on the head may fracture the internal table only, the external one and diploë escaping. This is difficult to diagnose, and thus it is impossible to judge of the severity of a fracture from the state of the external table. This may be whole, or merely cracked, while the internal shows many fragments, which may set up meningitis or other mischief.

Anatomical conditions tending to minimise the effects of violence inflicted upon the skull.—(1) The **density and mobility of the scalp.** (2) The **dome-like shape of the skull.** This is calculated to bear relatively hard blows and also to allow them to glide off. (3) The **number of bones** tends to break up the force of a blow. (4) The **sutures** interrupt the transmission of violence. (5) The **inter-sutural membrane** (remains of fœtal periosteum) acts, in early life, as a linear buffer. (6) The **elasticity of the outer table.** (7) The **overlapping of some bones,** e. g. the parietal by the squamous; and the alternate bevelling of adjacent bones, e. g. at the coronal suture. (8) The **presence of ribs, or groins,** e. g. (*a*) from the crista galli to the internal occipital protuberance; (*b*) from the root of the nose to the zygoma; (*c*) the temporal ridge from orbit to mastoid; (*d*) from mastoid to mastoid; (*e*) from external occipital protuberance to the foramen magnum. (9) **Buttresses,** e. g. zygomatic processes and the greater wing of the sphenoid. (10) The **mobility** of the head upon the spine.

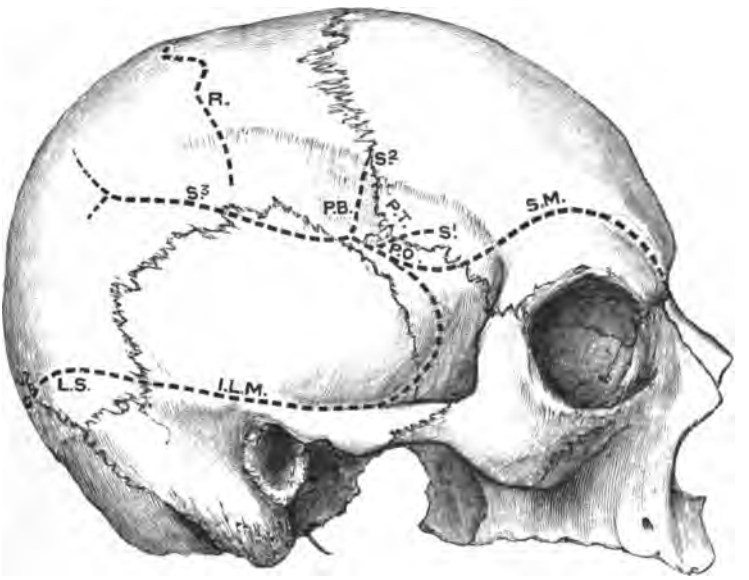
CRANIO-CEREBRAL TOPOGRAPHY

To make as clear as possible the points of practical importance which have, of late years, been put on a definite basis, and which the surgeon may have to recall and act upon at very short notice, cranio-cerebral topography will be spoken of under the following headings: A. **Relation of the brain as a whole to the skull.** B. **Relation of the chief sulci and gyri to the skull.** C. **Localisation of the**

chief sulci and gyri. Before alluding to the above, it is necessary to say distinctly that the following surface-markings and points of guidance are only approximately reliable, for the following reasons: (1) In two individuals of the same age and sex the sulci and convolutions are never precisely alike. (2) The relations of the convolutions and sulci to the surface vary in different individuals. (3) That as the surface area of the scalp and outer aspect of the skull are greater than the surface area of the brain, and as the convexities do not tally, lines drawn on the scalp or skull cannot always correspond precisely to cerebral convolutions or sulci. It results from the above that when a definite area of the surface is said to correspond accurately in any individual to a definite area of the brain surface, this result has been correlated from many examinations; and that as surface-markings, shape, and processes of skull and arrangement of surface are all liable to variations in different individuals, the surgeon must allow for these variations by removing more than that definite area of skull which is said to correspond exactly to that part of the brain which he desires to expose.

FIG. 931.—THE OUTLINE OF THE BRAIN AND ITS FISSURES IN RELATION TO THE SUTURES OF THE SKULL. (Cunningham.)

S.M. Supraciliary margin of the cerebrum. I.L.M. Infero-lateral margin of the cerebrum. L.S. Position of highest part of the arch of the transverse (lateral) sinus. R. Central sulcus (Fissure of Rolando). s^1. Anterior horizontal limb of lateral (Sylvian) fissure. s^2. Anterior ascending limb of lateral (Sylvian) fissure. s^3. Posterior horizontal limb of lateral (Sylvian) fissure. P.B. Opercular portion (Pars basilaris) of the inferior frontal convolution. P.T. Triangular portion of the inferior frontal convolution. P.O. Orbital portion of the inferior frontal convolution.



A. Relation of the brain as a whole to the skull (figs. 931 and 933).—To trace *the lower level of each cerebral hemisphere* on the skull, the chalk would start from the lower part of the glabella; thence the line pursues a course, slightly curved upwards, about a third of an inch above the supraorbital margin; next, crossing the temporal crest about half an inch above the external angular process, it passes not quite horizontally but descending slightly to a point in the temporal fossa just below the tip of the great wing of the sphenoid (pterion), 2·5 cm. (1 in.) behind the external angular process. From this point the line of the level of the brain, now convex forwards and corresponding to the anterior extremity of the temporal lobe, would dip down, still within the great wing of the sphenoid, to about the centre of the zygoma. Thence the line would travel along the upper border of this process about 6 mm. (¼ in.) above the roof of the external auditory meatus (p. 931), and thence just above the base of the mastoid and the posterior inferior angle of the parietal, and so along the superior curved line (p. 931), and corresponding to that of the tentorium and horizontal part of the transverse (lateral) sinus, to the external occipital protuberance.

The **upper margin of each hemisphere** would be represented by a line drawn from just below the glabella, sufficiently to one side of the middle line to allow for the falx and superior sagittal sinus, to one immediately above the superior external occipital protuberance and inion (p. 1270).

B. **Relation of the chief fissures and convolutions to the skull.** C. **Localisation of the chief sulci and gyri.** These headings will be taken together.

It will be well to first indicate the position of the chief **sutures** which mark off the parietal bone, under which lies that part of the brain which is most important to the surgeon—the motor area. The upper limit of the bone will be indicated by the line already spoken of as giving the upper margin of the hemisphere—the **sagittal line, or suture** (p. 1270). The anterior limit of the parietal bone, formed by the **coronal suture,** may be traced thus: The point where it leaves the sagittal suture (the bregma) will be found by drawing a line from a point just in front of the external auditory meatus (the pre-auricular point) (p. 1270, figs. 927 and 932) straight upwards on to the vertex; from this point a line drawn downwards and forwards to the middle of the zygomatic arch would indicate that of the coronal suture. Under this suture lie the posterior extremities of the three lateral frontal convolutions; for the frontal lobe lies not only under the frontal bone, but extends backwards under the anterior part of the parietal, the central sulcus (fissure of Rolando), which separates the frontal from the parietal lobe, lying from 3·7 to 5 cm. (1½ to 2 in.) behind the coronal suture at its upper extremity and about 2·5 cm. (1 in.) at its lower.

The squamoso-parietal suture, which marks the lower border of the anterior two-thirds of the parietal bone, is not so easy to define, owing to the irregularity and variations of its curve. Its highest point is usually 4·3 cm. (1¾ in.) above the zygoma.

The lambdoid suture, which forms the posterior boundary of the parietal bone, will be marked out by a line which starts from a point (lambda) (p. 1259) about 6·2 cm. (2½ in.) above the external occipital protuberance, and runs downwards and forwards to a point on a level with the zygoma, 3·7 cm. (1½ in.) behind and 1·2 cm. (½ in.) above the centre of the meatus.

The position of the chief sulci will now be given:—

Lateral (Sylvian) fissure (figs. 931 and 932).—The point of appearance of this, on the outer side of the brain, practically corresponds to the pterion (p. 1260, fig. 927)—a point which lies in the temporal fossa, about 3·7 cm. (1½ in.) behind the external angular process and about the same distance above the zygoma. From this point the lateral (Sylvian) fissure, which here separates the frontal and parietal from the temporal lobe, runs backwards and upwards, ascending gently, at first in the line of the squamo-parietal suture, then crossing this suture about its center, and thence, ascending more rapidly, it climbs up to the temporal ridge, to end 1·8 cm. (¾ in.) below the parietal eminence. Its termination is surrounded by the supramarginal convolution, to which the parietal eminence corresponds with sufficient accuracy. Such being the surface-marking of the chief or posterior horizontal limb of the lateral fissure (s^3, fig. 931), it remains to indicate briefly the two shorter limbs which bound the inferior frontal convolution, which, on the left side, contains the centre for speech (Broca's convolution), and corresponds to a point lying three fingers'-breadth vertically above the centre of the zygomatic arch. (Stiles.) Of these, the anterior horizontal (s^1, fig. 931) runs forwards across the termination of the coronal, just above the line of the spheno-parietal suture. The ascending limb (s^2, fig. 931) runs upwards for about 2·5 cm. (1 in.) just behind the termination of the coronal suture, or 5 cm. (2 in.) behind the external angular process. To indicate the lateral fissure (fissure of Sylvius), a line should be drawn from a point corresponding to the pterion (p. 1260, fig. 927) backwards, at first gently and then more abruptly upwards, 1·8 cm. (¾ in.) below the parietal eminence. The ascending limb (point of bifurcation) will start from a point 5 cm. (2 in.) behind and slightly above the external angular process, and run obliquely forwards and upwards for about 2·5 cm. (1 in.).

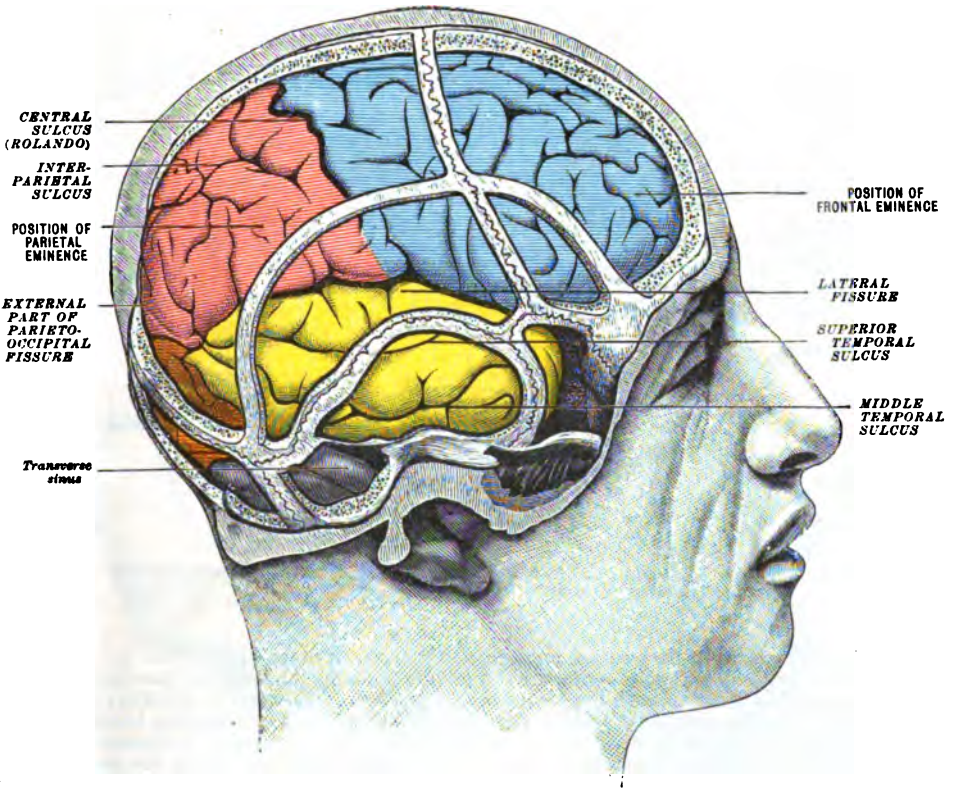
The central sulcus (fissure of Rolando).—This most important fissure, around which the motor area is grouped, runs downwards and forwards, separating the frontal and parietal lobes between the following points: The upper end of the fissure, **the upper Rolandic point,** will be found about 1·2 cm. (½ in.) behind the centre of the sagittal line (p. 1270)—a line drawn from just below the glabella to the external occipital protuberance. On the skull this upper Rolandic point will be nearly 5 cm. (2 in.) behind the bregma. The lower extremity of the fissure, the **inferior**

Rolandic point, would be about 1·2 cm. (½ in.) behind and a little above the bifurcation of the lateral fissure, i. e. 5 cm. (2 in.) behind and a little above the external angular process (fig. 933). Owing to the obliquity of the central sulcus (fissure of Rolando), this lower point will be nearer the coronal suture than the upper, being distant from it about 2·5 cm. (1 in.). A line about 9·3 cm. (3¾ in.) long, drawn between the upper and lower Rolandic points (the Rolandic line), will give the direction of the central sulcus with sufficient accuracy, when the two genua, the upper concave and the lower convex forwards (fig. 931), are allowed for. The Rolandic line forms with the sagittal line an angle anteriorly of 65° to 70°.

To find the central sulcus (fissure of Rolando) the following methods have been employed. In a given case it is well to employ them all, so that any error in one may be checked by another measurement:

I. The upper and lower Rolandic points are found as just directed, and the Rolandic line is drawn between them.

FIG. 932.—DRAWING OF A CAST OF THE HEAD OF AN ADULT MALE.
(Prepared by Professor Cunningham to illustrate cranio-cerebral topography.)

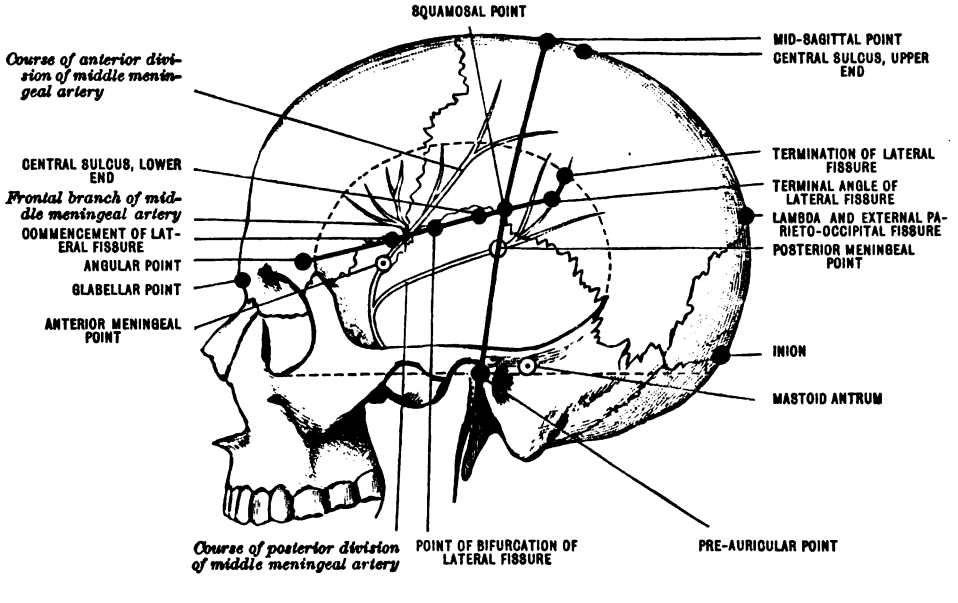


II. The upper Rolandic point is taken as before. The position of the lower end of the fissure is thus determined: From the very end of the external orbital process, where this rises up to join the temporal crest, draw a horizontal line 5·6 cm. (2¼ in.) long, and from the extreme end of this draw a vertical line of a little over 2·5 cm. (1 in.). Between these upper and lower Rolandic points, passing rather obliquely forwards, lies the central fissure. (Lucas Championnière.)

III. Here (1) the sagittal line is taken; (2) and (3) at a right angle to this two lines are drawn vertically over the side of the skull,—the one starting from the pre-auricular point (fig. 933), the other at the level of the posterior border of the mastoid process,—and meeting the sagittal line about 5 cm. (2 in.) behind the second; (4) from the junction of the lines 1 and 3, one is drawn diagonally downwards, reaching 2 about 5 cm. (2 in.) above and a little in front of the external auditory meatus. (Reid and Godlee.)

IV. The central sulcus may be found by the measurements given by Makins and Anderson (fig. 933). The chief cranial landmarks employed here are: (1) the **glabellar point;** (2) the **inial point;** (3) the **mid-sagittal point,** midway between these; (4) the **pre-auricular point,** in front of the tragus, on a level with the upper border of the external auditory meatus; (5) the **angular point,** over the external angular process, on a level with the upper border of the orbit; (6) the **squamosal point,** at the junction of the middle and lower thirds of the line, between the pre-auricular and mid-sagittal points. By the aid of these points, **three lines** may be drawn upon the shaven scalp definitely related to the principal fissures of the outer surface of the brain:—(1) The **sagittal line,** from the glabella to the inion. (2) The **squamosal line,** from the angular to the squamosal point, and about two inches beyond; in this line and its continuation lies the horizontal part of the fissure of Sylvius. (3) The **frontal line,** from the pre-auricular to the mid-sagittal point. The fissure of Rolando crosses this line at an acute angle. Its upper end, carried to the midline, lies three-eighths of an inch behind the mid-sagittal point; its lower end, in the squamosal line, three-eighths of an inch beyond the squamosal point.

FIG. 933.—CRANIO-CEREBRAL TOPOGRAPHY. (Anderson and Makins.)



Some further *points in the surgical anatomy of the cranium* must be referred to:—*The middle meningeal* artery. This vessel, entering the middle fossa by the foramen spinosum, grooves the great wing of the sphenoid and divides into two branches. The anterior grooves the anterior inferior angle of the parietal bone, and is then continued upwards and slightly backwards between the coronal suture and central sulcus (fig. 933), almost to the vertex; the posterior branch takes a lower level, running backwards under the squamous bone to supply the parietal and anterior part of the occipital bones. If a skull, bisected antero-posteriorly, be held up to the light, it will be seen how thin are the bones over the chief branches of this vessel, thus accounting for the slight violence sometimes sufficient to rupture it. The groove it occupies in the parietal is sometimes converted into a canal. A wounded artery retracting here may be very difficult to secure. The veins which accompany the artery are thin-walled and sinus-like before they open into the spheno-parietal sinus, another explanation of the obstinacy of this hæmorrhage. According to the point of rupture, three hæmatomata should be remembered (Krönlein), anterior or fronto-temporal; middle, or temporo-parietal; and posterior, or parieto-occipital. The first two are much the most frequent, and exposure of the pterion (p. 1260), with free removal of the adjacent bone, will suffice for dealing with them.

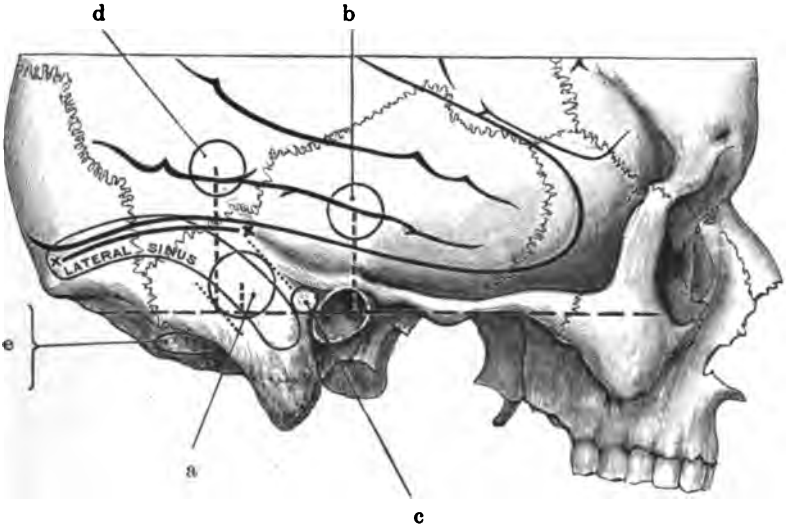
Fig. 934 and its accompanying letter-press show the different sites for **trephining** for those common complications of otitis media, viz., temporo-sphenoidal abscess, thrombosis of the lateral sinus, and cerebellar abscess.

Drainage of the lateral ventricle.—Where the anterior fontanelle is closed, Poirier and Keen have opened the descending cornu through the middle temporal convolution, the pin of the trephine being placed 3·1 cm. (1¼ in.) behind the external auditory meatus, and about the same distance above Reid's base-line. This point corresponds with sufficient accuracy to d, in fig. 933. The needle should here be directed to a point about 5 cm. (2 in.) above the opposite ear.

Up to this point the **outside** of the cranium has been mainly considered; it remains to draw attention to some of *the chief points in the surgical anatomy* of the **interior**, especially of **the base.** **The three fossæ** are of paramount importance in fracture. In the **anterior fossa** the delicacy of parts of the floor, the connection of this with the nose and orbit, and the exact adaptation of its irregular surface to that of the frontal lobes, no 'water-bed' intervening, are the chief points. Thus the slightness of a fatal fissure, the frequent presence of bruising after a blow perhaps on the occiput, which has been considered to have caused only concussion, the characteristic palpebral hæmorrhage, and the infection of a fracture here are all explained, together with the possibility and gravity of a fracture here from a severe blow on the nose. In the **middle fossa** the frequency of fractures is explained by the facts that while here, as in the other fossæ, a fracture often radiates down from the vertex, the overlying vault being a region often struck, the base is weakened by numerous foramina and fissures. Further, the resisting power of the petrous bone must be lessened by the cavities for the internal ear, the carotid,

FIG. 934.—SHOWING THE RELATIONS OF THE LATERAL SINUS TO THE OUTER WALL OF THE SKULL, AND THE POSITION OF THE TREPHINE-OPENING, a, FOR EXPLORING IT.

Reid's base-line is shown passing through the middle of the external auditory meatus and touching the lower margin of the orbit. x x indicate the site of the tentorium as far as it is in relation to the outer wall of the skull. The anterior x shows the point where the tentorium leaves the skull and is attached to the upper border of the petrous bone. a, Trephine-opening to expose transverse sinus, its centre being 1 in. behind and ¼ in. above the centre of the meatus. This opening can easily be enlarged upwards, backwards, downwards, and forwards (see the dotted lines) by suitable angular forceps. It is always well to extend it forwards so as to open up the mastoid antrum, c. b, Trephine-opening to explore the anterior surface of the petrous bone, the roof of the tympanum, and the petro-squamous fissure, its centre being situated a short inch above the centre of the meatus. At the lower margin of this trephine-opening a probe can be insinuated between the dura and the bone, and made to search the whole of the anterior surface of the petrous. c, Trephine-opening for exposing antrum, ¼ inch above and behind the centre of the meatus. d, Trephine-opening for temporo-sphenoidal abscess (Barker), 1½ inches behind and above centre of meatus. The needle should be directed at first inwards, and a little downwards and forwards. e, Trephine-opening for cerebellar abscess, 1½ inches behind and one inch below the meatus. The anterior border of the trephine should be just under cover of the posterior border of the mastoid process. Such an opening is well removed from the transverse sinus, and a needle, if directed forwards, inwards, and upwards, would enter an abscess occupying the anterior portion of the lateral lobe of the cerebellum, the usual site of an abscess in this part of the brain. (Barker.)



and, to a less degree, by the jugular fossa. For fluids to escape through the external meatus, the dura, the prolongation of the arachnoid into the internal meatus, the membrani tympani, and probably the internal ear, must all be injured. The presence of the middle meningeal artery (p. 1270) and the cavernous sinus in this fossa must also be remembered, especially in such operations as that on the Gasserian ganglion. **Posterior fossa:** It is not sufficiently recognised that fractures here are, owing to the anatomy of the parts, in some respects the most important of all. It is here that a small fissure-fracture, ultimately fatal, with severe occipital and frontal bruising and some intradural hæmorrhage, has been so often overlooked, especially in the drunken. This is explained by the supposed strength of the bone, this being really very thin in places, by the thickness of the soft parts, and the abundance of hair. Further, there is no very apparent escape of cerebral contents as in the anterior and middle fossæ. Blood, etc., may trickle into the pharynx far back, or a deep-seated ecchymosis coming up after two days, under the muscles about the mastoid process, may call attention to the damage within.

Dura mater.—This, described as acting as an endosteum, while bringing blood-vessels to the bone, lacks the chief power of periosteum elsewhere in that it has very little bone-producing power; the influence of its partitions and its damping effect on vibrations are great in blows on the head. Its varying adhesions, according to site and age, must be remembered. Thus while it is intimately connected over the base with its adhesions to the different foramina, it is more loosely connected with the vault, as is shown in middle meningeal hæmorrhage. In early and later life the closeness of its connection with the bones is also more marked. Its junction with the inter-sutural membrane has been referred to (p. 1265). Its relation to the arachnoid beneath, and then the origin of a pachymeningitis, sometimes salutary by shutting off the arachnoid, and a leptomeningitis, almost invariably fatal, must be remembered.

Finally, the existence of **the cerebro-spinal fluid** with its power of lessening the evil of vibrations and its aid in regulating intra-cranial pressure, must be borne in mind. The chief collections, in which the subarachnoid meshwork is almost absent, are met with in front and behind the medulla. That in front, also lying under the pons, Mr. Hilton's 'water-bed,' sends a prolongation forwards to the optic chiasma, but does not extend under the frontal lobes. The collection behind lies between the medulla and under surface of the cerebellum. Here, by the foramen of Magendie, this collection and, also, the intraventricular communicate with the subarachnoid space of the spinal cord.

THE FACE

The outline of the different bones—nasal, upper and lower jaws, zygomatic (malar), and zygoma—can be readily traced. The last mentioned and the glabella are alluded to on pp. 1259 and 1260; and the canine fossa should be identified as one of the antral routes. The delicacy, laxity, and vascularity of the skin are of great importance in all operations, while the abundance of large gland orifices accounts for the frequency of lupus here.

Arteries.—The **supraorbital artery** can be felt beating just above its notch (junction of inner with outer two-thirds of supraorbital arch); the little **frontal artery** is of importance, as it nourishes the flap when a new nose is taken from the forehead; the **temporal,** accompanied by the auriculo-temporal nerve, can be felt where it crosses the root of the zygoma just in front of the tragus, its anterior branch about 3·1 cm. (1¼ in.) above and behind the external angular process of the frontal; the **occipital,** accompanied by the great occipital nerve (p. 1286), pulsates to the inner side of the middle of a line drawn from the occipital protuberance to the mastoid process; the **posterior auricular,** rather deeply, between the auricle and the mastoid. The **external carotid** lies behind the ascending ramus of the jaw. The **external maxillary** (facial) (fig. 935) crosses the jaw just in front of the masseter; if divided, both ends must be secured here. It can be felt again a little behind the angle of the mouth, just beneath the mucous membrane (it here gives off the labial branches, which can also be felt, lying deeply, if the lip is taken between the finger and thumb); and again by the side of the nose, as it runs up to the tendo oculi. The small angular branch is, from its position, always troublesome to secure. To trace the course of the **external maxillary** (facial) artery a line should be drawn from a point a little above and outside the tip of the great cornu of the hyoid to the lower part of the anterior border of the masseter, and thence to one outside and above the angle of the mouth, and so onwards, external to the angle of the nose, up to the inner canthus. The **anterior facial vein** takes a straight course behind the tortuous external maxillary artery, the absence of valves, its communication by the angular and ophthalmic veins with the cavernous sinus, and, by the deep facial, with the pterygoid plexus, are of grave importance in infective thrombosis. The external jugular will be mentioned at p. 1286.

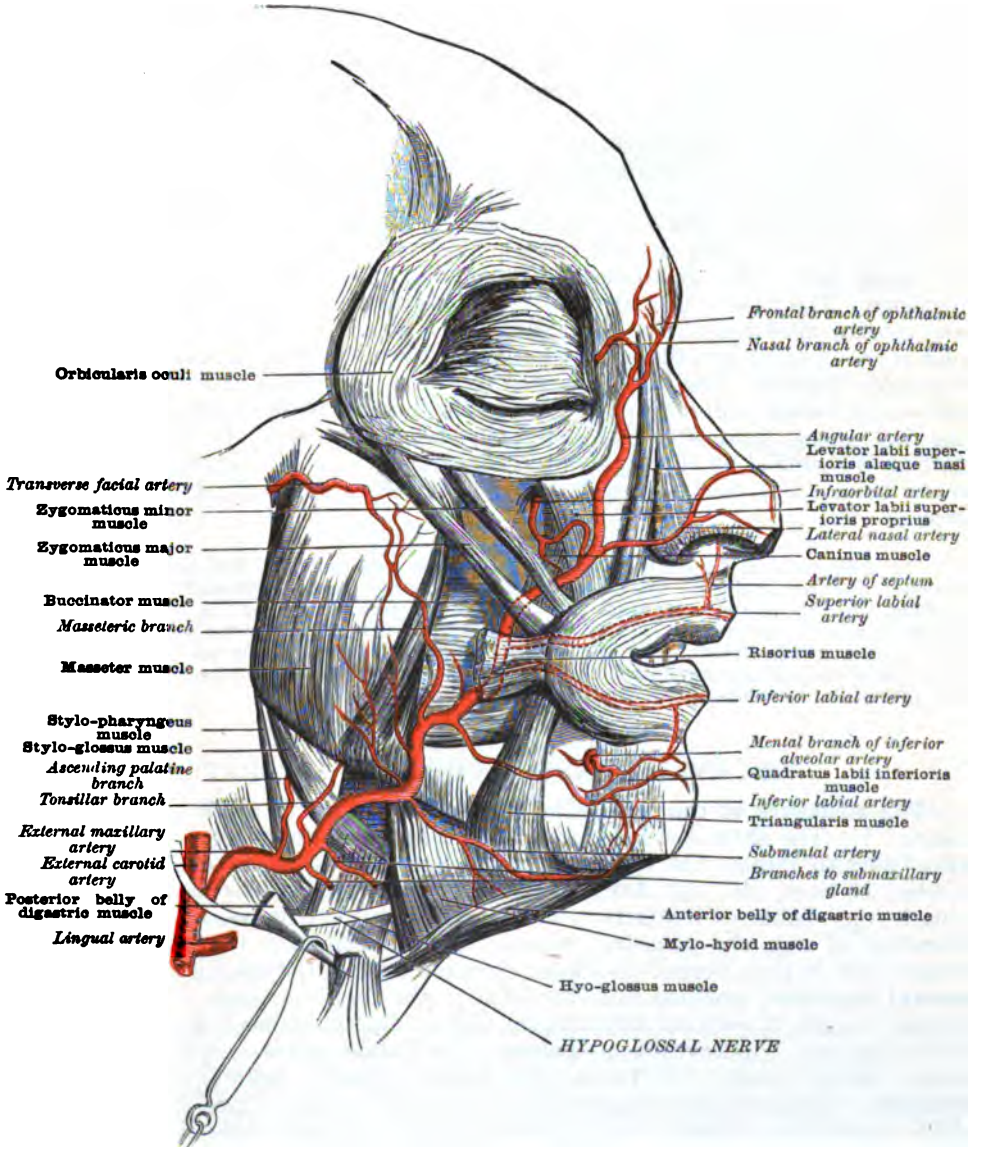
A line drawn from the lower border of the meatus to a point midway between the nose and upper lip gives the level of the **parotid duct,** which opens into the mouth opposite the second molar tooth. The level of the duct, somewhat inconstant, would be usually about a finger's breadth below the zygoma. It is accompanied by the transverse facial artery above, and the infraorbital branch of the facial nerve below. The **sheath of the parotid,** continuous with those of the masseter and sterno-mastoid, is strong enough to cause most exquisitely painful tension when inflammation of the gland is present, and, together with the presence of deep processes of the gland in connection with the mandibular (glenoid) cavity and styloid process, to explain the deep burrowing of pus which may take place into the pharynx and pterygoid region. The relation of the capsule to growths, innocent or malignant, of the parotid is also important.

The parotid region would be thus mapped out (fig. 938). *Above* by the pos-

terior two-thirds of the zygoma; *below*, by a line corresponding to the posterior belly of the digastric (fig. 938); *behind*, are the external auditory meatus, mastoid, and sterno-mastoid. *In front* the gland and socia parotidis overlap the posterior part of the masseter, to a variable degree (fig. 938).

Facial nerve.—In the petrous bone the course of this nerve is first outwards and forwards, then, having entered the facial canal, backwards and downwards along the inner wall of the tympanum, above the fenestra ovalis (p. 976). Emerging from the stylo-mastoid foramen the nerve takes first the line of the posterior belly of the digas-

FIG. 935.—SCHEME OF THE EXTERNAL MAXILLARY (FACIAL) ARTERY. (Walsham.)



tric, running forwards and a little downwards from the anterior border of the mastoid where this meets the auricle. (Godlee.) Entering at once the posterior part of the parotid, it crosses the neck of the mandible at the level of the lower border of the tragus.

The frequent paralysis of this nerve may thus depend upon—(1) cerebral causes; (2) disease of or injury to the petrous portion; (3) affections after its exit—Bell's paralysis. A diagnosis

may be arrived at by attention to the following. In cerebral disease the lower part of the face is chiefly affected, the eyelids usually escaping. In all the other forms the whole side of the face is paralysed. Hemiplegia of the opposite side of the body and paralysis of the sixth nerve are usually present. In petrous paralysis, owing to involvement of the chorda tympani, there may be interference with the saliva and taste, affecting especially the anterior part of the tongue. The auditory nerve may also be affected. Here and in (3) there will be a history of disease or injury. In complete paralysis the smooth side of the face and forehead, the absence of power of expression, to frown, to blow, or whistle, the open eyelids and epiphora, and subsequent liability to mischief in the cornea, the dropping of the angle of the mouth and dribbling of saliva, the interference with mastication from paralysis of the buccinator, are the chief points.

Mandible.—Dislocation of the temporo-mandibular joint is referred to on p. 212. In the usual **dislocation,** from muscular action, the jaw is suddenly brought forwards against the anterior part of the capsule, which tends, by the action of the depressors, to give way; the elevators then pull up the mandible, a sequence that must be remembered in reduction. In the commonest **fracture** of the mandible—unilateral, near the mental foramen—the larger anterior fragment will be pulled by the depressors downwards and inwards, the smaller posterior one upwards and usually outside the other fragment.

In trephining to expose the inferior alveolar (dental) nerve, one of the common seats of neuralgia and one in which a peripheral operation is justified from the results, the ascending ramus is opened midway between its anterior and posterior borders, on a level with the last molar.

Upper jaw.—The boundaries of the maxillary sinus (**antrum**) are of much importance. The base of this irregularly pyramidal cavity corresponds to the middle and inferior meatuses on the outer wall of the nose; towards the upper and back part is the opening into the middle meatus. The apex runs outwards towards the zygomatic process. The root is formed by the orbital plate with the infraorbital nerve and vessels anteriorly; the floor by the junction of the alveolar arch, carrying the first molars (and often the bicuspids), with the hard palate. Anteriorly, the antrum is bounded by the canine fossa; posteriorly it is in relation with the zygomatic fossa. The cavity, present at birth, increases gradually up to the twelfth year.

The chief paths of infection are through the teeth (especially the first and second molar), the nose, and frontal sinus. The obstinacy of inflammation here is explained by the site of the opening, high up on the inner wall, and thus inadequate drainage, by the imperfectly multilocular cavity of the interior and its rigid walls. The two chief sites for *opening the antrum* are—(*a*) through the sockets of the first or second molars; (*b*) through the canine fossa, after the reflection of mucous membrane has been detached, midway between the roots of the teeth and the infraorbital foramen. This path gives more room.

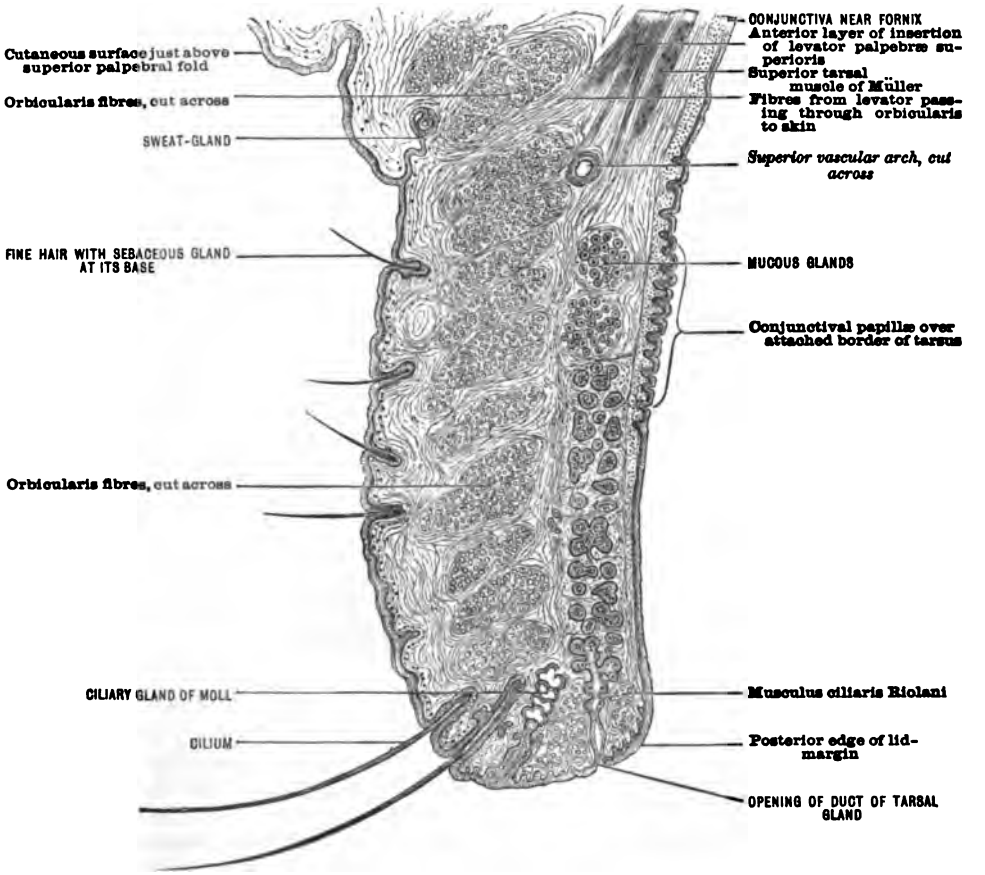
THE EYELIDS AND LACHRYMAL APPARATUS

The structure of the lids.—The different layers are of much practical importance. (1) The **skin** is delicate and fatless, and contains pigment, the object of this being to protect the eye from bright light. It helps to explain the 'dark circles' of later life. (2) **Areolar tissue.** Owing to its looseness and delicacy, this is very liable to infiltration, as in ascites and erysipelas. (3) **Orbicularis.** Paralysis of this, the palpebral portion, leads to epiphora, the puncta being no longer kept in their normal backward direction against the conjunctiva. (4) **Palpebral ligament,** reaching from the orbit to the tarsal cartilage. This is usually strong enough to prevent hæmorrhage, due to fractured base of skull, becoming subcutaneous. (5) **Levator palpebræ.** (6) **Tarsal plate;** in reality, densely felted fibrous tissue. (7) **Tarsal** (Meibomian) **glands, lashes,** and **sebaceous follicles.** Localised inflammation starting in any of these three structures, especially the last, will cause a 'stye.' The frequency with which the lid-border is the seat of that most troublesome chronic inflammation, blepharitis, and its result, 'blear eye,' is explained by these anatomical points. Its circulation is terminal and slow; half skin and half mucous membrane, it is moister and more liable to local irritation than the skin; while its numerous glands readily participate in any inflammation. (8) **The conjunctiva.** To trace this important membrane, the lids should be everted, when the following will be noted. The conjunctiva over the tarsal part of the lid is closely adherent, and through it a series of nearly straight, parallel, light yellow lines and granules, the tarsal (Meibomian) glands, can be seen.

Owing to their position here (fig. 936) and to avoid scarring, a tarsal cyst is always opened on its conjunctival surface. Beyond the tarsi, the conjunctiva, now palpebral, is thicker and freely movable, owing to the abundant submucous tissue. Underlying vessels are visible here. Tracing the conjunctiva onwards over the sclerotic, the former becomes thinner and contains very few vessels, any present still moving with it (conjunctival).

In glaucoma the episcleral vessels, the veins especially, are well seen, dark and dusky looking. At the junction of the palpebral and sclerotic conjunctivæ is the reflexion called the fornix. On this reflexion in the upper lid open the lachrymal ducts, one to twelve, from the two portions of the gland. Traced onwards over the cornea, the conjunctiva becomes thinned down to a mere epithelial layer, closely adherent to the subjacent parts.

FIG. 936.—VERTICAL TRANSVERSE SECTION THROUGH THE UPPER EYELID. (After Waldeyer and Fuchs.)


CONJUNCTIVA NEAR FORNIX
Anterior layer of insertion of levator palpebræ superioris
Superior tarsal muscle of Müller
Fibres from levator passing through orbicularis to skin
Superior vascular arch, cut across
Cutaneous surface just above superior palpebral fold
Orbicularis fibres, cut across
SWEAT-GLAND
FINE HAIR WITH SEBACEOUS GLAND AT ITS BASE
MUCOUS GLANDS
Conjunctival papillæ over attached border of tarsus
Orbicularis fibres, cut across
CILIARY GLAND OF MOLL
CILIUM
Musculus ciliaris Riolani
Posterior edge of lid-margin
OPENING OF DUCT OF TARSAL GLAND

The vessels of the lids, scarcely visible in health, give two chief indications of disease. In conjunctivitis the well-known bright red network is due to enlargement of the *conjunctival* vessels (from the palpebral). When the mischief is more intraocular, e. g., in the deeper part of cornea, iris, or ciliary body, a circumcorneal zone is present in which the colour is inclined to pink, and the vessels largely straight and not moving with the conjunctiva. The vessels here are *subconjunctival* or *episcleral*, and derived from the anterior ciliary, which in their turn come chiefly from the muscular branches. These branches take a large share in the nutrition of the cornea, and are responsible for the vascularity of pannus and the 'salmon patches' of keratitis.

The differing structure of the palpebral and ocular portions has important bearings. Thus the palpebral is thick, highly vascular, and very sensitive. To this vascularity we owe the chemosis, or hot, red, tense swelling of purulent ophthalmia. The exquisite suffering of the same disease, or that caused by a foreign body, is explained by the numerous nerve-papillæ and end-bulbs. To the thickness and abundance of the connective tissue are due the contraction and permanent thickening which may occur in granular lids. The so-called granulations, met with in this disease on the palpebral conjunctiva, are really little nodules of hypertrophied lymphoid follicles, or mucous glands, which abound here.

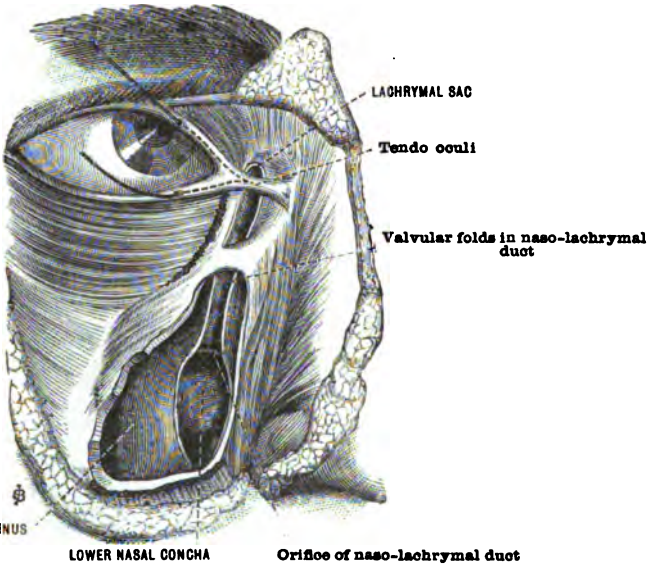
In an account of the eyelids the important ocular fascia or **capsule of Tenon** should be referred to. Together with the conjunctiva it must be opened in the operation of strabismus, and in enucleation of the eyeball the two must be divided around the cornea, where they are intimately blended. In removal of the upper jaw the attachment of the suspensory ligament of this fascia must always be left, if possible, otherwise the eyeball will tend to fall forwards and the cornea suffer from its exposure. (Lockwood.) Finally, the cavity between the two layers of the capsule is continuous with the extensions of the cerebral membranes along the optic nerve, i. e., with both the subdural and the subarachnoid space.

The **position of the lachrymal puncta** should be noted; owing to their backward direction, the lids must be previously everted. The puncta are kept open by a minute fibrous ring.

Each is situated on a minute papilla at the junction of the inner and straight third of the lid with the outer curved two-thirds. Close to the inner canthus, in addition to the puncta and papillæ, should be noted the caruncula lachrymalis, with its delicate hairs, and the plica semilunaris, which corresponds to the third eyelid of certain birds.

The **lachrymal sac** is the most important of the lachrymal apparatus, from its disfiguring diseases; it lies in a bony groove, between the nasal process of the max-

FIG. 937.—THE LACHRYMAL APPARATUS AND NASO-LACHRYMAL DUCT. (Bellamy.)
(Bristles are introduced into the puncta lachrymalia.)



illa and the lachrymal bone. The tendo oculi crosses it a little above its centre (fig. 937). Thus two-thirds of the sac are below the tendon, and in suppuration the opening is made below it also. The angular artery ascends on the nasal side of the sac. The **manipulation of a probe along the lachrymal passages** should thus be practised:—the lower lid being drawn outwards and downwards by the thumb, the probe is passed vertically into the punctum, then turned horizontally and passed on till it reaches the inner wall of the sac. It is then rotated somewhat forwards, raised vertically, and pushed gently along the duct downwards, and a little outwards and backwards, till the floor of the nose is reached, the operator aiming, as it were, for the site of the first molar tooth.

If the eyes are opened naturally, the greatest part of the cornea, behind it the iris, with the pupil in the centre, on either side of the cornea some of the sclerotic, the semilunar fold, and caruncle can be seen.

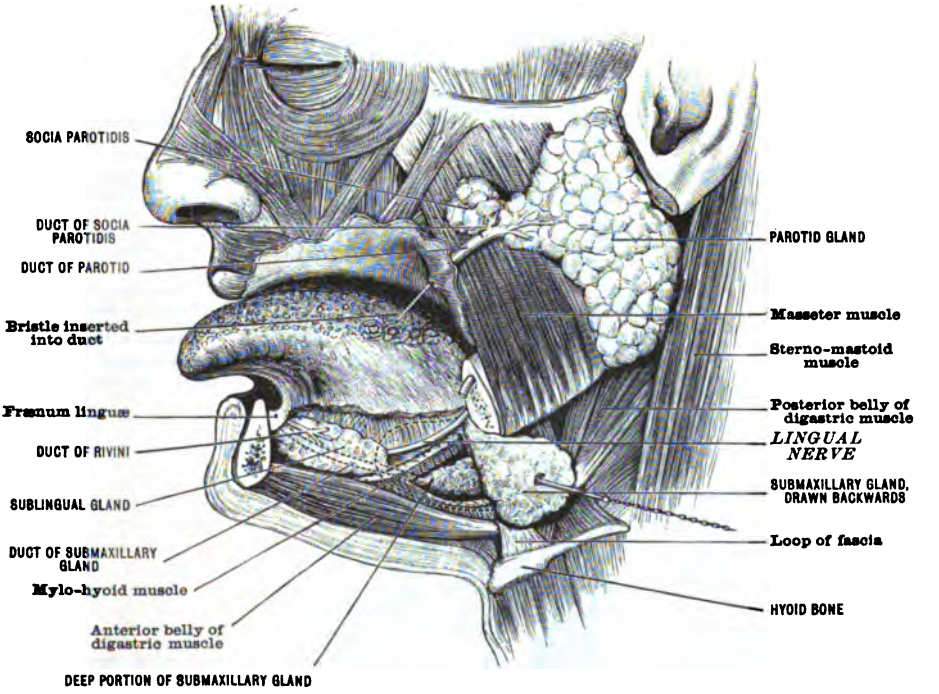
THE MOUTH

If the tongue be raised, the under surface is seen to be smooth and devoid of papillæ. In the middle line is the **frenum.** When division of this is really required

in tongue-tie, the scissors should be kept close to the bone, in order to avoid the ranine vessels. Of these, the veins can be seen just to one side; the arteries are close by, but deeper. Farther out are two more or less distinct fringed folds, the fimbriæ plicatæ, running from behind forwards, and, like the frenum, disappearing before the tip. Between these and the frenum are the small apical mucous glands of Nuhn or Blandin. Farther back, at the junction of the mucous membrane and the alveoli, are two other projections of the mucosa, the sublingual; under these are the sublingual glands, the ranine veins, and, more deeply, Wharton's duct and the termination of the lingual nerve. The majority of the ducts of the sublingual gland (Rivinian) open on the sublingual ridges. A single larger one, Bartholini's, opens with that of Wharton, or close to it, on either side of the frenum (fig. 938).

Dilatation of one of the Rivinian ducts, more frequently dilatation of a muciparous gland,—and, much more rarely, dilatation of Wharton's duct,—constitutes a 'ranula.' The **submaxillary gland** can be felt nearer the angle of the jaw, lying between its fossa and the mucous membrane, especially if pressure is made from outside. The attachment of the **genio-glossi** can be felt behind the sym-

FIG. 938.—SIDE OF THE FACE AND MOUTH CAVITY, SHOWING THE THREE SALIVARY GLANDS.

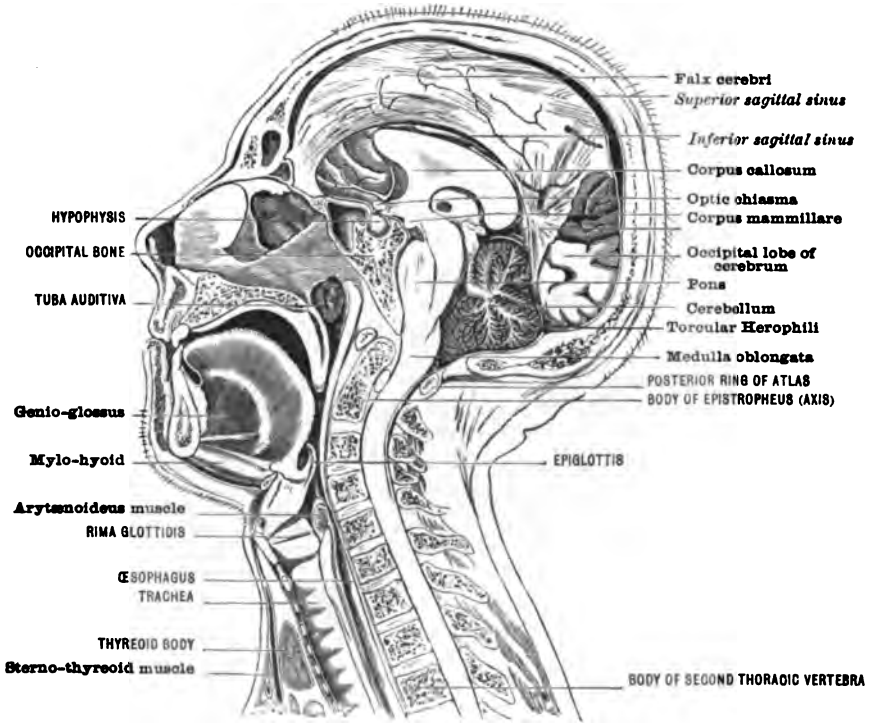


physis: the division of the muscles allows the tongue to come well out of the mouth; but when both have to be divided, the tongue loses much of its steadiness, and may easily fall back over the larynx during the administration of the anæsthetic or, later on, in sleep. It should therefore be secured forwards for a while with silk. For the same reason, in removal of one-half of the mandible, part of this muscular attachment should always be left, if possible. Turning now to the dorsum of the tongue, this shows two distinct parts: one, the anterior two-thirds, *the buccal*, is rich in papillæ; the other, the posterior, *the pharyngeal*, contains abundant lymphoid follicles like the tonsil. This part possesses peculiar sensibility, as shown by movements of tongue and palate when a depressor is placed too far back. Containing the upper remains of the thyreo-glossal duct, it may be the seat of lingual thyreoid growths. The two parts are separated by the V-shaped arrangement of the vallate papillæ, with the apex turned backwards. While the tongue is mainly a muscular organ, the fine fatty connective tissue in the septum and between the muscular bundles is the seat of that dangerous condition acute glossitis, and of gummatous infiltration. While the mouth is widely open, the pterygo-mandibular liga-

ment can be seen and felt beneath the mucous membrane, behind the last molar tooth. Just below and in front of the lower attachment of this ligament the **lingual nerve** can be felt lying close to the bone below the last molar. The simplest and surest method of dividing the nerve here, to give relief from pain in incurable carcinoma of the tongue, is to draw the tongue out of the mouth and expose the nerve where it lies superficially under the mucous membrane thus made prominent between the side of the tongue and the gums, the centre of the incision being opposite to the last molar tooth. (Roser, Létiévant.)

Behind the last molar tooth can be felt the **coronoid process,** and higher up, just behind and inside the tooth, the **hamular process of the sphenoid.** This process is a landmark to the site of the posterior palatine canal, which lies just in front of it, and which transmits the posterior and descending palatine branch of the internal maxillary, together with the anterior or great palatine nerve. The vessel and nerve run forwards in grooves, giving off anastomosing branches towards the middle line, and join at the incisive foramen with the naso-

FIG. 939.—SECTION OF THE SKULL AND BRAIN IN THE MEDIAN PLANE. (Braune.)



palatine artery. Their position must be remembered in raising the flaps during the operation for closure of a cleft in the hard palate. To ensure the vitality of the flaps the incisions must be made outside the vascular arch, close to and parallel with the upper alveolus, and should not extend beyond a point opposite to and just internal to the last molar tooth, for fear of encroaching upon the posterior palatine canal.

When the teeth are clenched, there is still a space, communicating between the mouth and pharynx behind the molar teeth, which admits a medium-sized catheter. When a patient breathes deeply through the mouth and the head is thrown back, the soft palate is raised, the pillars are separated, and the uvula and fauces, with the anterior and posterior pillars, with their attachments, the tonsils, and the back of the pharynx are exposed. This portion of the pharyngeal mucous membrane would lie over the lower part of the second and the upper part of the third cervical vertebræ, the anterior arch of the atlas corresponding to the level of the posterior nares, and the body of the epistropheus (axis) to the level of the soft

palate (fig. 939). If a finger be introduced past the soft palate to this part of the spine and turned upwards and downwards, it is possible, with the aid of an anæsthetic, to examine the upper four or five and, in children, six vertebræ, as far as the anterior surfaces of their bodies. 'The part of the column which is accessible to a straight instrument introduced through the mouth is very limited, extending, in the adult, from the lower border of the axis to the middle or lower part of the fourth cervical vertebra; in the child, owing to the small size of the face, it comprises the bodies of the axis and of the third cervical vertebra.' (Thane and Godlee, from Chipault.)

The lymphatic drainage of the face, mouth, and tongue is given at pp. 709 and 713.

Tonsils.—The **relations of the tonsils** should be carefully examined. Thus, they are separated externally by the superior constrictor and pharyngeal aponeurosis from the ascending pharyngeal and internal carotid arteries. The latter vessel lies about 2·5 cm. (1 in.) behind and to the outer side of the tonsil. When serious hæmorrhage follows operations here, it usually comes from one of the numerous tonsillar branches (fig. 410). The extent to which the tonsil is covered by the anterior pillar, how far it projects upwards beneath the soft palate or downwards into the pharynx, have all important bearings on the mode of removal. Its position corresponds to a point a little above and in front of the angle of the jaw. The outer surface, enclosed by an imperfect capsule and separated from the superior constrictor by connective tissue, explains how an enlarged tonsil can be dragged inwards by a vulsellum, and enucleated after an incision in the mucous membrane around. It is in this connective tissue that severe infective inflammation, e. g., after scarlet fever or an imbedded pipe-stem, may set up hæmorrhage or spreading cellulitis, retro-pharyngeal or otherwise.

The **finger introduced downwards at the back of the mouth,** especially if the parts are rendered insensitive by eucaine, feels the vallate papillæ, the lingual and laryngeal surfaces of the epiglottis, the arytæno-epiglottidean folds, with the cuneiform and corniculate cartilages. **If the finger be moved upwards** behind the soft palate and turned upwards to the base of the skull, and then forwards, it will impinge on the posterior nares, separated by the vomer. The other boundaries of these are, externally, the internal pterygoid plate and palate bones; above, the basi-sphenoid; and below, the horizontal plate of the palate bone and the inferior nasal spine. Within each nostril would be felt the posterior ends of the two lower nasal conchæ (turbinate bones); above and behind is felt the basilar process of the skull, the vault of the pharynx, and upper cervical spine (fig. 939).

The size of the nares, in the bony skull 2·5 cm. (1 in.) vertically by 1·2 cm. (½ in.), and the presence of any adenoids, are especially to be noted. The **richness of the naso-pharynx in glandular structures,** its proneness to inflammation, and of this inflammation to spread to other parts,—e. g., the tympanum,—are well known. The finger should be familiar with the feel of adenoids—i. e., hypertrophied post-nasal lymphatic nodules—soft bodies of irregular shape blocking up the naso-pharynx. To make out how far this is the case, it is well to take the nasal septum as the starting-point.

THE PALATE

Between the diverging pillars of the soft palate is the **isthmus faucium,** bounded above by the free margin of the palate, and below by the dorsum of the tongue. The space between the pillars, glosso-palatine and pharyngo-palatine, with attachments denoted by their names, shallow above, widens and deepens below. Of its lateral boundaries, the posterior pillars come nearer each other than the anterior. The coverings of the hard palate are chiefly mucous membrane, glands, and periosteum. These are intimately blended by fibrous septa, as in the superficial layers of scalp and palm of the hand. Hence the readiness with which necrosis takes place here.

In paring the edges of a cleft soft palate, the following structures would be, successively, cut through:—(1) Oral mucous membrane; (2) submucous tissue, with vessels, nerves, and glands; (3) glosso-palatine muscle; (4) aponeurosis of tensor palati; (5) anterior fasciculus of pharyngo-palatine; (6) levator palati and uvular muscles; (7) posterior fasciculus of pharyngo-palatine; (8) submucous tissue, vessels, nerves, and glands; (9) posterior

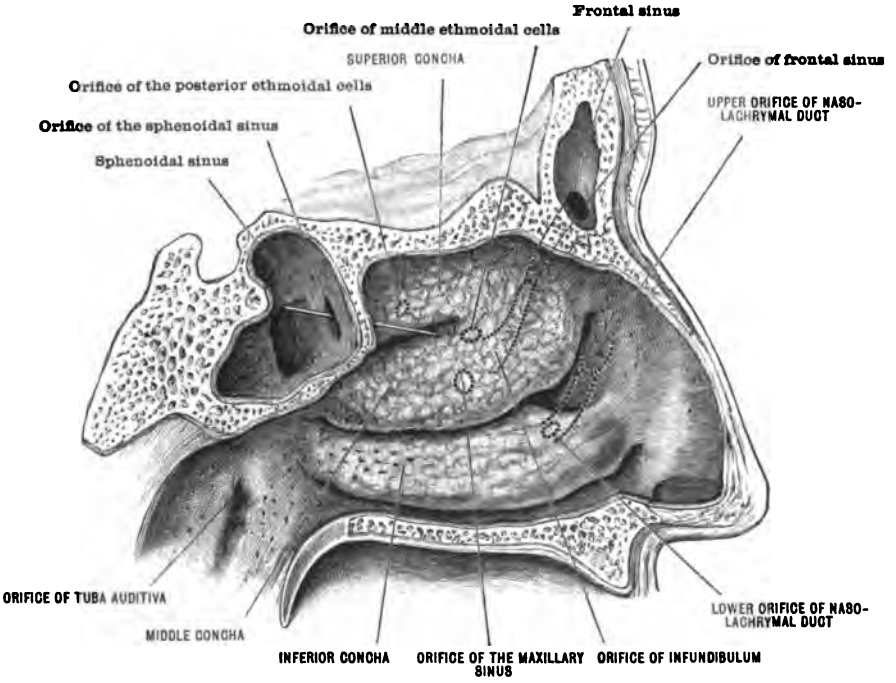
mucous membrane. The soft palate is thicker than it seems, the average in an adult being 6 mm. (¼ in.). The muscles widening a cleft are the tensor and levator, while the superior constrictor closes it in swallowing. Of the *arteries* of the palate, from the external maxillary (facial), ascending pharyngeal, and internal maxillary, the largest is the descending palatine branch of the last. This emerges from the posterior palatine canal close to the inner side of the last molar tooth (p. 531).

THE NOSE

On the face the outline of the nasal bones can be easily traced, and below them the upper lateral cartilages, flat and also somewhat triangular. Below these are the lower lateral cartilages, curved and so folded back that each forms an outer and an inner plate. Of these, the inner meet below the septal cartilage to form the tip of the nose, while the outer curve backwards, and, together with dense masses of cellular tissue and fat and accessory cartilages, form the alæ.

With the speculum, especially if the head be thrown back and the tip of the

FIG. 940.—SECTION OF THE NOSE, SHOWING THE CONCHÆ (TURBINATE BONES) AND MEATUSES WITH THE OPENINGS IN DOTTED OUTLINE.

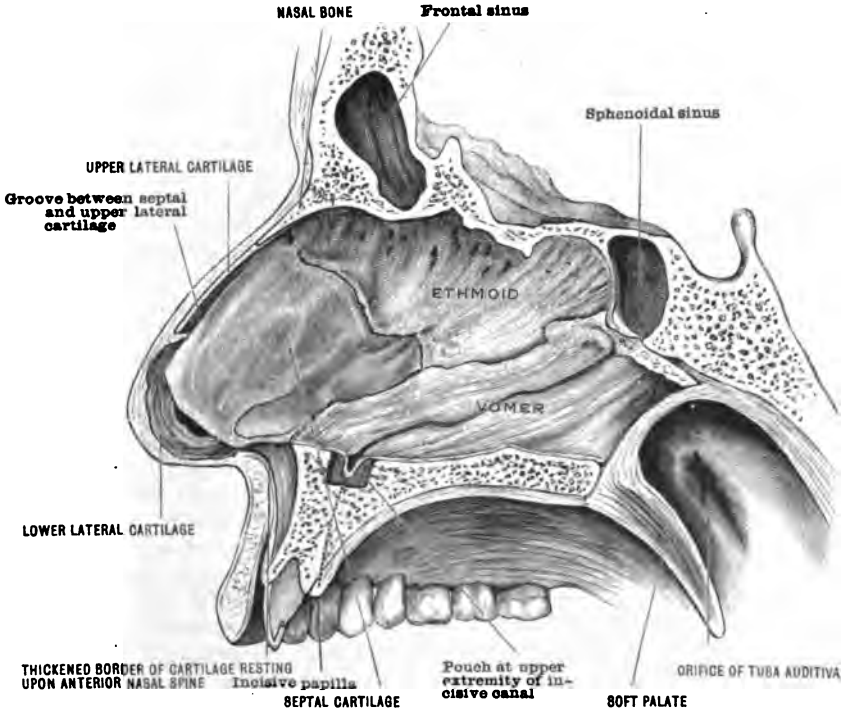


nose drawn up, the lower part of the septum, floor of the nose, and greater portion of the inferior concha (turbinate bone) can be seen. On throwing the head further back, with a good light the lower margin of the middle concha can also be made out. This is much higher up and nearly on a level with the root of the nasal bone. The septum often deviates to one side. The mucous membrane over it is, in health, dull red in colour; that over the inferior concha is thicker. The anterior extremity of the latter bone is about 1·8 cm. (¾ in.) behind the orifice, while the opening of the nasal duct is about 2·5 cm. (1 in.) behind and about 1·8 cm. (¾ in.) above the floor, concealed by the anterior extremity of the inferior concha. The opening into the maxillary sinus (antrum) is situated in about the centre of the middle meatus and 2·5 cm. (1 in.) above the floor.

The **olfactory area of the mucous membrane** extends over the highest concha and upper part of the middle, and corresponding portions of the septum. The **respiratory portion** is more vascular and thicker, especially over the conchæ. It is firmly adherent to the periosteum and perichondrium. The veins, especially over the lower conchæ, form a dense plexus, closely resembling cavernous tissue. This

fact explains the severity of epistaxis, and, together with the drainage of blood into out-of-the-way veins, such as the spheno-palatine and ethmoidal, accounts for the serious results which may follow on a firmly impacted and infected plug. The boundaries of the posterior nares have been given at p. 1179. About 1·2 cm. (½ in.) behind the extremities of the inferior conchæ, just above the level of the hard palate (fig. 939), on the side of the naso-pharynx, are the openings of the *tubæ auditivæ* (**Eustachian tubes**). Oval in shape, these are bounded above and behind by the prominence of the cartilage, which is wanting below, thus facilitating the entry of a

FIG. 941.—SECTION SHOWING BONY AND CARTILAGINOUS SEPTUM.
The dotted line indicates the course of the incisive (anterior palatine) canal.



catheter. The lower part of the tube contains in early life lymphoid tissue; enlargement of this explains the deafness in certain cases of adenoids. At the upper part of the naso-pharynx, on the posterior wall, extending down laterally as far as the tubæ auditivæ, is the collection of lymphoid tissue known as the **pharyngeal tonsil,** and when hypertrophied, playing a large part in 'naso-pharyngeal adenoids.' From the periosteum of the basi-sphenoid and basi-occipital arise naso-pharyngeal fibromata.

THE NECK

Landmarks in the middle line.—The body of the hyoid is nearly on a level with the angles of the jaw, and the interval between the third and fourth cervical vertebræ (fig. 939). It divides the front of the neck into supra- and infra-hyoid regions, convenient for remembering the distribution of the deep fascia. On either side of the body are the great cornua. The upper borders of these are the guides to the lingual arteries. The outline and mobility of the body and the great cornua are easily determined by relaxing the deep fascia and pushing the bone over to the opposite side. Below the hyoid is the thyreo-hyoid space, which corresponds with the epiglottis and the upper aperture of the larynx. Thus, if the throat be cut above the hyoid, the mouth will be opened and the tongue cut into; if the thyreo-hyoid space be cut, the pharynx would be opened and the epiglottis wounded near its base. In the former case the lingual and external maxillary are the most likely

vessels to be wounded; in thyreo-hyoid, the commonest cut-throat, the superior thyreoid vessels, and the superior laryngeal nerve. The projection of the thyreoid notch, about 2·5 cm. (1 in.) below the hyoid, is much more distinct in men than in women or children. It does not appear before puberty, and thus flatness of the thyreoid must be expected when the landmarks for tracheotomy are sought for in children with short fat necks. The cricoid, on the other hand, is always to be made out. It corresponds in horizontal plane to the following:—(1) The fifth cervical vertebra. (2) The junction of pharynx and œsophagus: from the narrowing of the tube here, foreign bodies may lodge at this point and cause dyspnœa by pressing on the air-tube in front. The cricoid is taken as the centre of the incision in œsophagotomy, and also for ligature of the common carotid. (3) The junction of larynx and trachea. (4) The crossing of the omo-hyoid over the common carotid. (5) The middle cervical ganglion. Above the cricoid is the crico-thyreoid membrane. In laryngotomy, the deepest part of the incision should be kept to the middle line for fear of injuring the crico-thyreoids, and as near the cricoid as possible, so as to avoid the neighbourhood of the vocal chords and the little crico-thyreoid vessels. The space is always small, and, after middle life, increasingly rigid.

The distance between the cricoid and the manubrium is only about 3·7 cm. (1½ in.). When the neck is stretched, about 1·8 cm. (¾ in.) more is gained. Thus, as a rule, there are not more than seven or eight tracheal rings above the sternum. Of these, the second, third, and fourth are covered by the thyreoid isthmus. The parts met with in the middle line—(*a*) above, and (*b*) below, the isthmus—high and low tracheotomy—should be borne in mind: (*a*) Skin, superficial fascia, branches of transverse cervical and infra-mandibular nerves, lymphatics, cutaneous arteries, anterior jugular veins,—with their transverse branches smaller above,—deep fascia, sterno-hyoids, cellular tissue, superior thyreoid vessels, and tracheal layer of deep fascia. The importance of this last is two-fold, as, first, the tube in tracheotomy may be passed between it and the trachea, and after a wound in this region this layer, continuous with the pericardium, may conduct discharges into the mediastina. (*b*) The surface structures are much the same, but the anterior jugular veins and their transverse branches are much larger. The inferior thyreoid veins are also larger. A thyroidea ima may be present, and the innominate artery, especially in children, may be 1·2 cm. (½ in.) above the sternum. The trachea is also smaller, deeper, and less steadied by muscles. The thymus, too, in young children, may prove a difficulty. Thus, in children, the high operation, incising the cricoid and crico-tracheal membrane, if needful, is to be preferred. The cricoid is, however, not to be incised, if possible; the higher the tube is inserted, the greater the irritation.

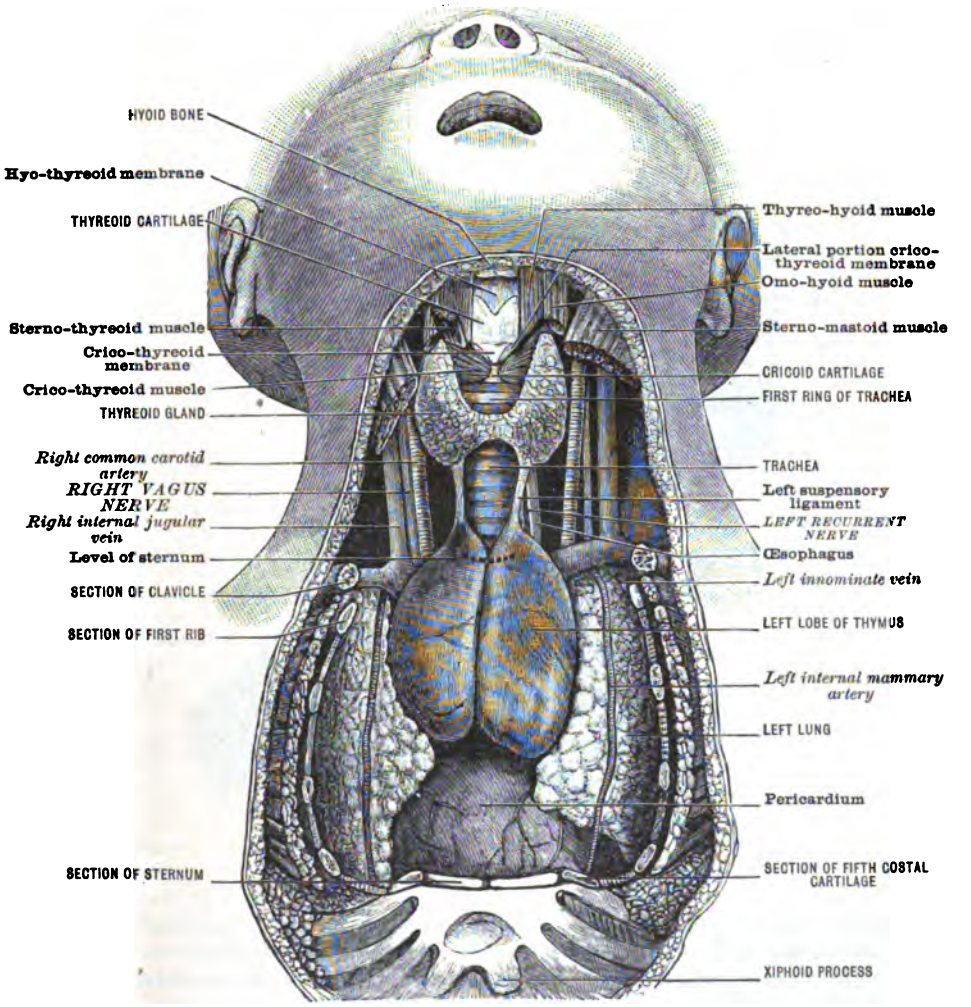
The **thyreoid gland** enclosed in a capsule of deep fascia derived from the pre-tracheal layer (p. 1290) is closely connected by this to the upper trachea and larynx. The upper somewhat pointed extremity of each lateral lobe reaches to the upper and back part of the thyreoid cartilage; here enter the superior thyreoid vessels. The lower layer and rounded extremity reaches to the fifth or sixth tracheal ring; its posterior and lower aspect is in relation to the inferior thyreoid vessels and the recurrent nerve; the lateral lobe, posteriorly, also overlaps the carotid sheath, which may be infiltrated in malignant disease of the thyreoid. The thyreoidea ima has been mentioned above. The isthmus in the adult is opposite to the second, third, and fourth tracheal rings. At its upper border is an arterial arch formed by the superior thyreoids; over the anterior surface of the gland and isthmus the inferior thyreoid veins take origin in a plexus. The upper border of the thymus (fig. 942) may be in relation with the lower border of the isthmus. From the upper border of the latter, the pyramidal lobe, especially on the left side, is often present, reaching by a pedicle to the hyoid. The pyramidal lobe, when present, is the persistent remnant of the thyreo-glossal duct, and occasionally cystic outgrowths persist obstinately as remnants of this duct, in the middle line, above, behind, and below (the commonest form) the hyoid bone.

The **sterno-mastoid** is the landmark for several important operations. Its inner border, the thicker and better marked of the two, overlaps the carotids; the common carotid corresponding, as far as the upper border of the thyreoid, with a line drawn from the sterno-clavicular joint to midway between the mastoid process and the angle of the jaw. The artery can be best compressed above the level of the cricoid, as here it is less deeply covered. The transverse process of the sixth cervical vertebra is called the carotid tubercle, after Chassaignac, who advised com-

pression of the carotid at this point. This process lies 5 to 7·5 cm. (2 to 3 in.) above the clavicle. Compression below it will command the vertebral as well. The student should recall the deep relations of the sterno-mastoid, which he may classify as vessels, nerves, muscles, glands, and bones; or, according to their position, (1) those above the level of the angle of the jaw; (2) those between the angle of the jaw and the omo-hyoid; (3) those below the omo-hyoid.

Of the two heads of the sterno-mastoid, the sternal is the thicker and more prominent, the clavicular the wider. A stab through the interval which lies between the two heads might wound the bifurcation of the innominate on the right

FIG. 942.—THYMUS GLAND IN A CHILD AT BIRTH.



side, and the common carotid on the left, the internal jugular, vagus, and phrenic veins, according to the direction of the wound.

The **anterior jugular,** commencing in branches from the submaxillary and submental regions, descends at first in the superficial fascia between the middle line and anterior border of sterno-mastoid, perforates the deep fascia just above the clavicle, here entering Burns's space (p. 1290); it then curves outwards to pass beneath both origins of the sterno-mastoid a little above the clavicle, to end usually in the external jugular. When distended, a large communicating branch between it and the common facial, which runs along the anterior border of the sterno-mastoid, must always be remembered in operations for removal of glands, etc. The varying level at which the external jugular crosses the outer border of the clavicular origin must be re-

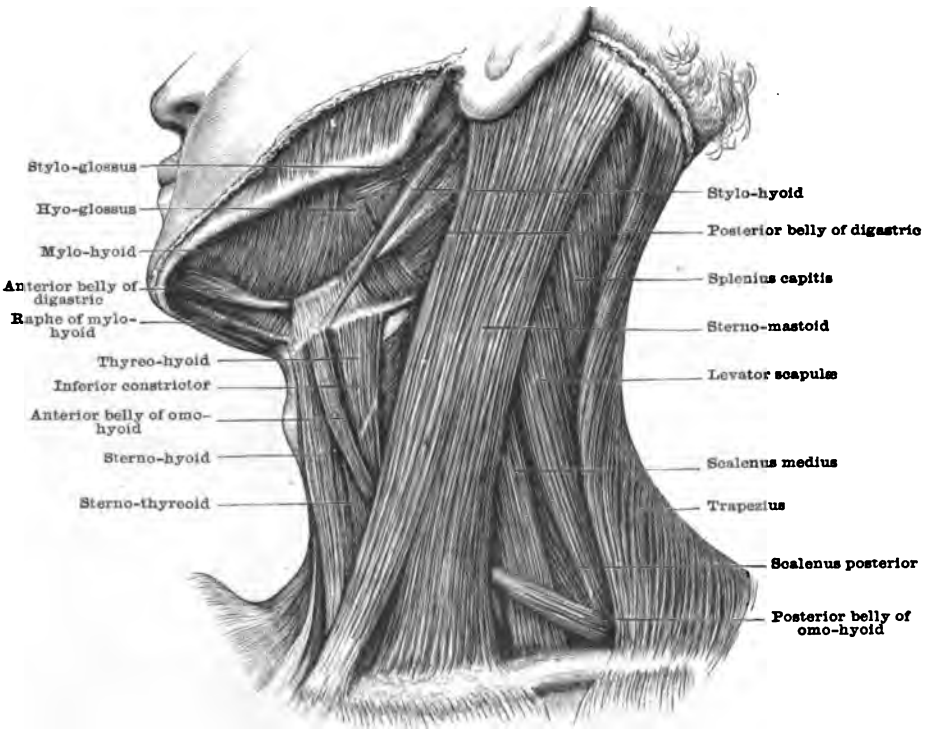
membered in such operations as tenotomy here. These veins vary in size inversely to each other; the anterior jugulars are joined by numerous transverse branches, and become larger below. They have no valves.

Of the chief arteries to the sterno-mastoid, that from the superior thyreoid will be divided in ligature of the common carotid; that from the occipital runs with the spinal accessory nerve.

Behind the sterno-clavicular joint lies the commencement of the innominate veins, the bifurcation of the innominate artery on the right, and the common carotid artery on the left; deeper still lie the pleura and lung.

In front of the sterno-mastoid is the **anterior triangle,** which is **subdivided into three smaller triangles** by the digastric muscle above, and the anterior belly of the omo-hyoid below (fig. 943). These smaller triangles are called, from above, the submaxillary, the superior and inferior carotid triangles. The **submaxillary** or **digastric triangle** is bounded above by the jaw, and a line drawn back to the mas-

FIG. 943.—ANTERIOR AND LATERAL CERVICAL MUSCLES.



toid process; below, by the digastric and stylo-hyoid muscles; and in front by the middle line of the neck. This space contains the submaxillary gland, and embedded in the gland is the external maxillary (facial) artery, the facial vein lying superficial to the gland; deeper than the gland are the submental vessels and the mylo-hyoid vessels and nerve. Posteriorly, and separated from the above structures by the stylo-mandibular ligament, which subdivides the triangle into a submaxillary and parotid part, is the upper part of the external carotid artery running up into the parotid gland, where it gives off its two terminal and the posterior auricular branches. More deeply lie the internal jugular vein, internal carotid artery, and the vagus. The floor of the triangle is formed by the mylo-hyoid, hyo-glossus, and superior constrictor. The lingual artery may be tied here, or, better, in order to get behind the dorsalis linguæ, close to its origin, by an incision similar to that for exposing the external carotid (p. 1285). The lymphatic nodes of the neck are described at p. 710.

The **hypoglossal** is a guide to the carotids and the occipital artery at the lower border of the digastric, and farther forwards, to the lingual, from which it is separated by the hyo-glossus.

The **superior carotid triangle** is bounded above by the digastric, below by the omo-hyoid, and behind by the sterno-mastoid. It contains the upper part of the common carotid and its branches, the external being at first somewhat anterior to the internal. All the branches of the external carotid, save the three just given, are found in this space, together with their veins, the internal jugular vein, the vagus and sympathetic nerves, and, for a short distance, the spinal accessory, together with those nerves which lie in front of and behind the carotids.

Ligature of the common carotid is usually performed at the 'seat of election,' where the vessel is more superficial, *above the omo-hyoid*. An incision with its centre opposite the cricoid is made 7·5 cm. (3 in.) long in the line of the artery (p. 1282). The deep fascia along the anterior border of the sterno-mastoid having been divided, the cellular tissue beneath is opened up, the omo-hyoid identified and drawn down or divided. The sterno-mastoid is next drawn well outwards, and the artery felt for. At this stage, such veins as the communication between the common facial and the anterior jugular and the superior and middle thyreoids may give trouble. The sheath is next opened well to the inner side, opposite to the cricoid cartilage, the ascending cervical, when seen, being avoided. If the internal jugular be distended, it may be drawn aside with a blunt hook, or pressure made lightly in the upper angle of the wound. The needle should be passed from the outer side in very close proximity to the outer and back part of the artery, so as to avoid the vein and vagus. Ligature *below the omo-hyoid* is rendered more difficult by the presence of the anterior jugular, the pretracheal muscles, an overlapping thyreoid gland, especially if enlarged, the greater depth of the artery, especially on the left side, and, here also, the closeness of the internal jugular. The *collateral circulation* is given at p. 1289. Ligature of the external carotid, otherwise difficult, is rendered very simple by first exposing the bifurcation of the common trunk (p. 1282), the incision similar to the last being prolonged upwards. Here the facial and lingual veins and hypoglossal nerve cross the trunk, over which also lie some of the deep cervical glands. The ligature is usually placed between the superior thyreoid and lingual branches. It is well to tie these and any other branches that can be got at for fear of secondary hæmorrhage, if the wound becomes infected.

Allusion must here be made to **the chief structures liable to be met with in operations on the neck.** These are the **internal jugular,** the **spinal accessory,** and **phrenic** nerves, the **vagus** and **hypoglossal,** the **thoracic duct,** low down and deep on the left side, the **œsophagus** and **recurrent nerve** in difficult operations on the thyreoid gland. Of these, the **internal jugular** is, in some ways, the most important. Glands, tuberculous or epitheliomatous, are often adherent to its sheath, especially those which drain the submaxillary group. When this condition is present or suspected, it is always well to begin the dissection low down in the inferior carotid triangle, where the structures are probably normal and the landmarks easy to identify. In infective thrombosis of the transverse sinus the internal jugular is often tied opposite to the cricoid cartilage, being either divided between two ligatures, or, if the thrombus has extended downwards, as much of the vein as is possible is removed. This vein contains only a single pair of valves low down in the neck. In all operations here on it and the other two jugulars, the risk of entry of air is to be remembered. The **spinal accessory** and **phrenic nerves** are alluded to at p. 1287.

The **inferior carotid** or **tracheal triangle** is bounded above by the omo-hyoid, behind by the sterno-mastoid, and in front by the middle line of the neck. It contains the lower part of the carotid sheath and its contents, with, behind it, the inferior laryngeal nerve and inferior thyreoid vessels, and to the inner side the trachea, thyreoid gland, and œsophagus. More deeply are the vertebral vessels; on the left side is the thoracic duct.

The position of the **branches of the external carotid** should be remembered. The great cornu of the hyoid and the ala of the thyreoid are landmarks for the origin of most of them. The **superior thyreoid,** arising just below the level of the great cornu of the hyoid bone, passes downwards and forwards to the back part of the thyreoid cartilage and upper part of the thyreoid body. Many of its branches are important in surgery. The **superior laryngeal** perforates the thyreo-hyoid membrane. The **sterno-mastoid** passes outwards into the middle of the muscle, across the carotid sheath. The **crico-thyreoid** crosses the space of the same name just below the lower border of the thyreoid cartilage. The little **hyoid** branch runs to the lower border of the hyoid bone. Anastomosing branches of the superior thyreoid form an arch along the upper border of the isthmus. The **lingual** artery arises from the parent trunk, opposite the tip of the great cornu of the hyoid, and passes forwards just above the great cornu, crossed by the hypoglossal, and thence to the side of the tongue. In the first part of its course, before it reaches the hyo-glossus, it is curved, at first ascending, and then, having descended slightly, before it reaches the hyo-glossus, and while it lies under it, its curve is gentle, with the concavity upwards; beyond the hyo-glossus, as it lies on the muscles of the tongue beneath the mucous membrane, it is tortuous. The **lingual vein,** it will be remembered, does not run with its artery, but lies superficial to the hyo-glossus. It receives the two small venæ comites, which run with the lingual itself just before it

crosses the common carotid. The line of the **external maxillary (facial) artery** (fig. 935), which often arises with the lingual, has been given on p. 1272. The **occipital artery** (fig. 944), starting on the same level as the facial (i.e., at a point a little above and outside the tip of the great cornu of the hyoid bone), follows a line drawn upwards and outwards, first to the interval between the transverse process of the atlas and the mastoid process, the former bone being felt just below and in front of the tip of the latter; thence, lying in the occipital groove of the mastoid, the artery ascends gradually, enters the scalp, together with the great occipital nerve, a little internal to a point midway between the external occipital prominence and the mastoid process, to follow, tortuously and superficial to the aponeurosis, the line of the lambdoid suture (p. 1268).

The surface marking of the **digastric** and **omo-hyoid,** which subdivide the anterior triangle into the three smaller subtriangles above described, should be noted. The line of the **posterior belly of the digastric** corresponds to one drawn from the apex of the mastoid process to a point just above the junction of the great cornu and body of the hyoid bone; and from this spot, which gives the point of meeting of the two tendons, one slightly curving upwards to a point just behind the symphysis menti, would give that of the **anterior belly.**

To trace the **omo-hyoid,** a line should be drawn from the lower margin of the side of the hyoid bone obliquely downwards, so as to cross the common carotid opposite the cricoid cartilage, and thence curving outwards under the sterno-mastoid at the junction of its middle and lower thirds, and then onwards and still outwards, parallel with and a little above the clavicle, as far as its centre.

Posterior triangle.—This shows in its lower part a wide depression, the supra-clavicular fossa. Here the brachial plexus may be felt, and, by pressure downwards and backwards immediately behind the clavicle, just outside and behind the outer margin of the sterno-mastoid, the pulsation of the subclavian artery can be stopped against the first rib. The supra-clavicular fossa should be opened out by depressing the arm, and the parts relaxed by carrying the shoulder forwards and turning the head to the same side. This vessel curves upwards and outwards from behind the sterno-clavicular joint to disappear behind the centre of the clavicle, the highest point of the curve being 1·2 to 2·5 cm. (½ to 1 in.) above the bone. The artery on the left side lies more deeply than the right, and does not rise so high into the neck. The subclavian vein lies at a lower level, separated by the scalenus anterior, and under cover of the clavicle. Into the above curve rise the pleura and lung. The pleura must be expected to rise 2·5 cm. (1 in.) above the clavicle, behind the clavicular head of the sterno-mastoid.

The **transverse scapular** and **transverse cervical vessels** run outwards, parallel with the clavicle. The former lies behind the bone and subclavius; the latter also runs transversely outwards, across the root of the neck, but on a slightly higher plane, and thus a little above the clavicle.

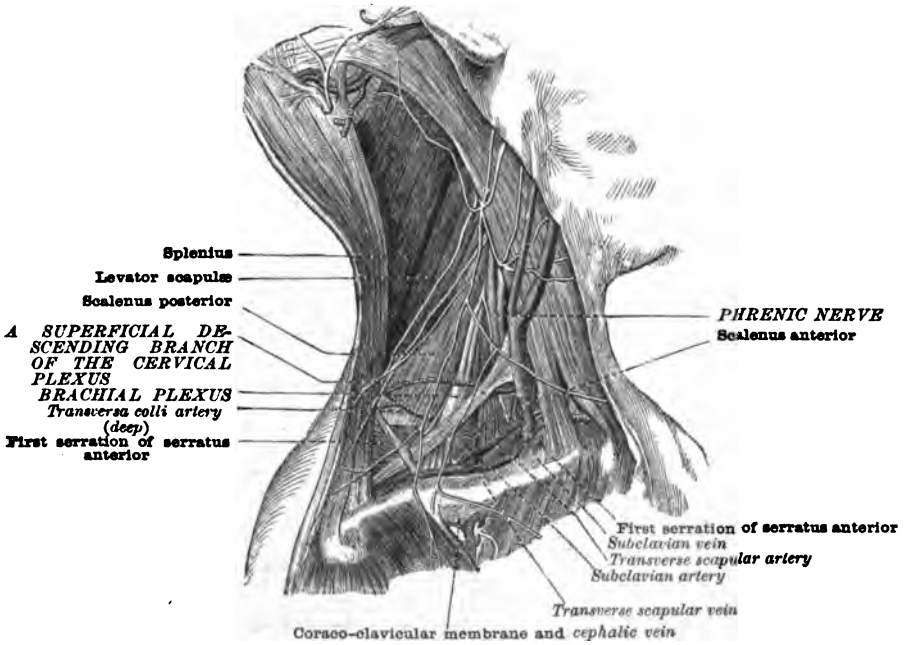
Ligature of the third part of the subclavian is best performed by an angular incision, the horizontal portion along the centre of the clavicle, and the vertical one along the posterior border of the sterno-mastoid, with partial division of this and the trapezius when closely adjacent. The chief points to bear in mind are the venous plexus into which the external jugular, transverse cervical, supra-scapular, and cephalic veins enter; the omo-hyoid and division of the fascia which ties this to the clavicle; identification of the outer margin of the scalenus anterior and the scalene tubercle; care of the transverse (supra-scapular) artery and the descending branch of the transverse cervical. The needle is passed from above downwards so as not to include the lowest cord of the brachial plexus, the vein, if distended, being depressed with a blunt hook. If the nerve to the subclavius be seen, it must be uninjured, as it occasionally forms an important part of the phrenic. The *collateral circulation* is given at p. 1289.

Crossing the sterno-mastoid a little obliquely, in a line drawn from a point just below and behind the angle of the jaw which marks its origin in the union of the posterior part of the internal maxillary and the posterior auricular veins to the centre of the clavicle, runs the **external jugular vein.** Above, it lies between the platysma and deep fascia, and is accompanied by the group of superficial cervical nodes (p. 707). About 3·7 cm. (1½ in.) above the clavicle it perforates the deep cervical fascia, its coats being blended with the opening. Gentle pressure with a finger at this point renders the vein above clearly visible. The dilated part between this point and the subclavian vein is called the sinus, and is marked by two valves, neither of which is usually perfect.

Opening into the external jugular, in the middle or lower third of its course, is the **posterior external jugular,** a vessel which begins in the occipital region superficially and runs down in front of the anterior border of the trapezius, across the posterior triangle.

The **spinal accessory,** having crossed the transverse process of the atlas, a point lying a little below and in front of the apex of the mastoid, enters the anterior border of the sterno-mastoid at about the junction of the upper and middle thirds of the muscle. Having traversed the muscle obliquely, it leaves it usually at a point a little lower down, pursues a similar course across the posterior triangle, disappears under the anterior border of the trapezius, to enter into the subtrapezial plexus with the third and fourth cervical nerves. Above it is accompanied by a branch from the occipital, below by the transverse cervical artery. It is always seen in thorough operations on the upper deep cervical glands. The nerve is resected in spasmodic torticollis, and in recent years inveterate facial paralysis has been treated by anastomosing the facial to this nerve or the hypoglossal. A line drawn from midway between the tip of the mastoid and the angle of the mandible along the above given

FIG. 944.—REGION OF THE THIRD PART OF THE SUBCLAVIAN ARTERY. (Bellamy.)
(The shoulder represented depressed.)



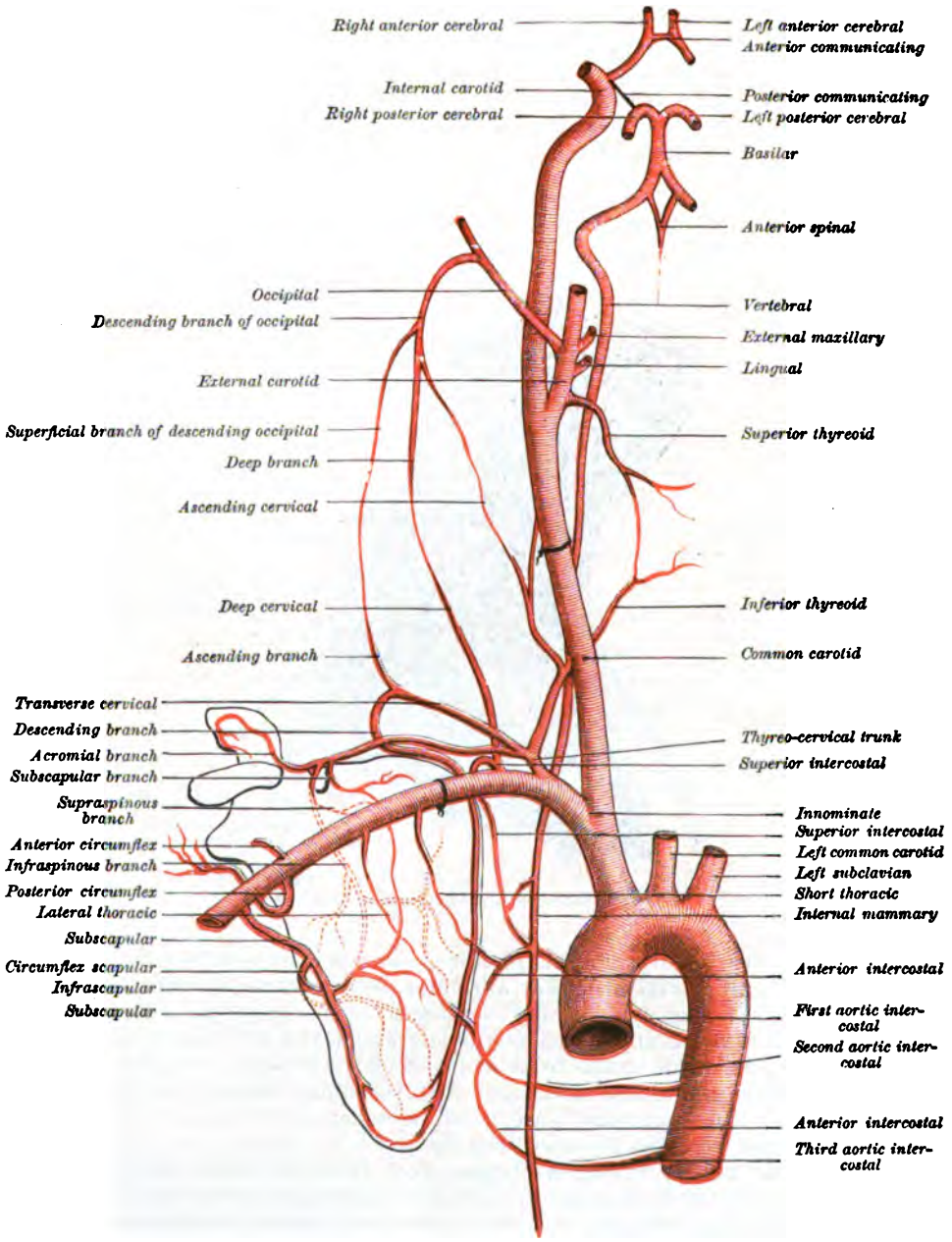
course of the nerve would denote its position. Just above the centre of the sterno-mastoid, the **small occipital, great auricular,** and **cutaneous cervical nerves** emerge, the first passing upwards and backwards to the scalp, the second upwards and forwards across the upper part of the sterno-mastoid to the ear, and the last turning straight forwards to the front of the neck. The small occipital and great auricular are often in intimate association with the spinal accessory at its exit from the muscle. At this point also care must be taken not to injure the nerve in removal of glands from the posterior triangle.

The **phrenic nerve,** taking its largest root from the fourth cervical, would begin deeply about the level of the hyoid bone; thence descending under the sterno-mastoid, and, passing obliquely inwards across the scalenus anterior (the posterior borders of the above two muscles roughly correspond to each other in the lower part of the neck), it descends under the subclavian vein and clavicle to enter the thorax. When the internal jugular is distended, its outer border will be liable to overlap this nerve. The relations of the *scalenus anterior* should be noted here. In addition to the phrenic, which runs with a slight obliquity inwards and is in close

contact with the muscle, the following structures cross it from within outwards: the subclavian vein and termination of the external jugular, the transverse scapular and transverse cervical vessels, and the omo-hyoid. At its inner margin are the thyreo-cervical trunk (thyreoid axis) and vertebral arteries, and over them, the internal jugular. Behind it are the subclavian artery, the brachial plexus, and pleura.

FIG. 945.—THE COLLATERAL CIRCULATION AFTER LIGATURE OF THE COMMON CAROTID AND SUBCLAVIAN ARTERIES.

(A ligature is placed on the common carotid and on the third portion of the subclavian artery.)



The level of the **brachial plexus** (upper border) would be given by a line drawn from the cricoid cartilages to the centre of the clavicle. The lowest, inner cord (eighth cervical and first thoracic, giving off chiefly the ulnar, inner head of median, and medial antibrachial cutaneous) is just above and behind the subclavian artery.

Its importance in ligature of the artery has been referred to (p. 1286). The first evidence of an exostosis from the first rib (scalene tubercle) may be gangrene of the little and part of the fourth fingers. (Hilton.) On the other hand, in paralysis of the newly born, after some violent manipulation, it is usually the upper and outer cord (fifth nerve, and axillary and median chiefly) which suffers, elevation and abduction at the shoulder and flexion at the elbow-joint being lost.

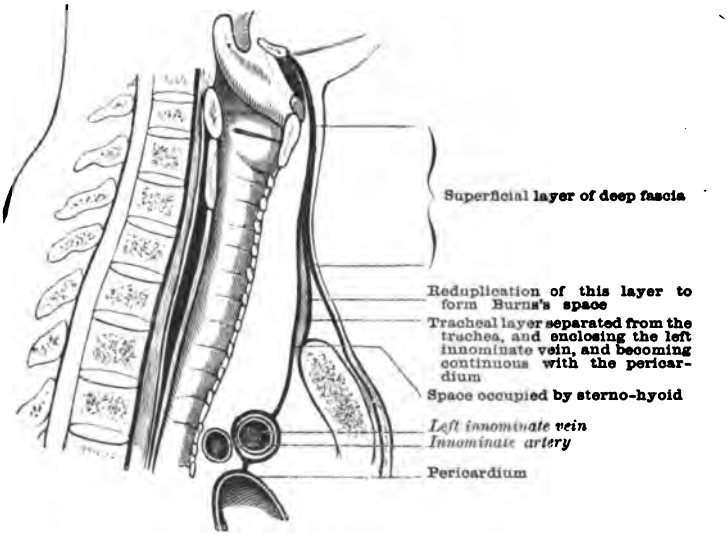
Collateral circulation after ligature of the common carotid (fig. 945).—This takes place by means of (1) the free communication which exists between the opposite carotids, both without and within the cranium; and (2) by enlargement of the branches of the subclavian artery on the same side as that on which the carotid has been tied. Thus, outside the cranium, the superior and inferior thyreoids are the chief vessels employed (fig. 945). Within the cranium the vertebral replaces the internal carotid.

Collateral circulation after ligature of the second and third parts of the subclavian (fig. 945).—Here the following three sets of vessels are those chiefly employed:—

The transverse scapular (suprascapular), the transverse cervical,	with	The thoraco-acromial, infra- and subscapular, and circumflex (dorsal) scapular.
The superior intercostal, the aortic intercostals, and the internal mammary,	with	The lateral (long) thoracic and subscapular arteries.
Numerous unnamed branches passing through the axilla from branches of the subclavian,	with	Branches of the axillary.

FIG. 946.—DIAGRAM OF THE LAYERS OF THE DEEP CERVICAL FASCIA IN AN ANTERO-POSTERIOR SECTION OPPOSITE TO THE STERNUM. (Tillaux.)

(The prevertebral layer can be seen passing down in front of the longus colli.)


Superficial layer of deep fascia
Reduplication of this layer to form Burns's space
Tracheal layer separated from the trachea, and enclosing the left innominate vein, and becoming continuous with the pericardium
Space occupied by sterno-hyoid
Left innominate vein
Innominate artery
Pericardium

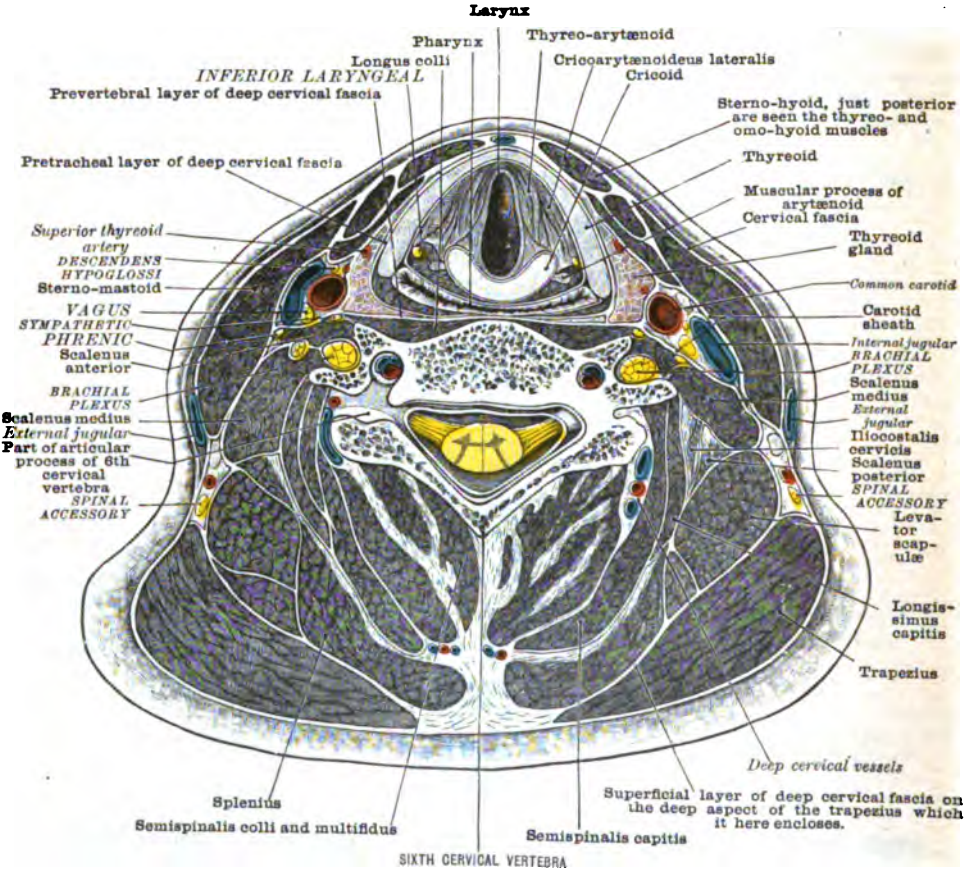
Deep cervical fascia.—The arrangement of this must be remembered—(*a*) above, and (*b*) below, the hyoid bone. The latter is far more important.

(*a*) **Arrangement above the hyoid bone.**—Here two chief processes can be made out:—(i) one, continuous with that in front of the sterno-mastoid, traced upwards from the hyoid bone, encloses the submaxillary gland, passing over the mylo-hyoid, and, ascending, is connected with the lower border of the mandible, gives off the masseteric and parotid fasciæ, and is attached to the lower border of the zygoma, and, more posteriorly, to the mastoid and superior curved line. (ii) A special process, which forms the stylo-mandibular ligament, is important in its power of checking over-action of the external pterygoid. By both these processes the anterior border of the sterno-mastoid is tied firmly forwards to the mandible about its angle, and more deeply to the styloid process. This renders all operations under the upper part of the muscle, e. g., the removal of glands, extremely difficult.

(*b*) **Below the hyoid bone** (fig. 946).—The importance of the fascia here is infinitely greater. **Four processes** must be remembered: (i) **Superficial;** (ii) **Pretracheal;** (iii) **Prevertebral;** (iv) **Carotid.** (i) **Superficial.** This starts from the

ligamentum nuchæ, encases the trapezius, forms the roof of the posterior triangle, where it is perforated by branches of the superficial cervical nerves and the external jugular vein. Passing on, it encloses the sterno-mastoid; and, passing over the anterior triangle, it meets its fellow in the middle line. Thin behind, it is thickened anteriorly. Behind this thickened union lie the anterior jugular veins. Below, at a varying distance below the thyreoid cartilage, this layer divides into two, attached to the front and back of the manubrium. Between these (**Burns's space**) lie some fat, a small gland, a communicating branch between the anterior jugulars and a small portion of the veins, and the sternal heads of the sterno-mastoids. The sheath to the depressors of the hyoid bone is partly derived from this layer, partly from the next. Laterally, this layer gives a sheath to the posterior belly of the omo-hyoid, is attached to the clavicle, and passing on, is continuous with the sheath to the

FIG. 947.—SECTION OF NECK THROUGH THE SIXTH CERVICAL VERTEBRA. (Braune).



subclavius and coraco-clavicular (costo-coracoid) fascia. (ii) **Pretracheal or middle.** This lies under the depressors of the hyoid, over the trachea, also encasing the thyreoid gland. Farther out it helps, together with the prevertebral, to form the carotid sheath. Traced downwards, the pretracheal layer passes over the trachea into the thorax (middle mediastinum). As it descends, it encases the left innominate vein, and ends by blending with the fibrous layer of the pericardium. Mr. Hilton suggested that the attachment of this fascia above, and that of the central tendon of the diaphragm below, to the pericardium served to keep this sac duly stretched, and so prevented any pressure of the lungs upon the heart. (iii) **Prevertebral.** This layer passes over the longus colli and capitis (rectus capitis anticus major) upwards to the base of the skull, and downwards over the longus colli behind the œsophagus into the posterior mediastinum. Laterally it helps to form the carotid sheath, and, lower down, gives a sheath to the subclavian artery and so to the axil-

lary. (iv) **The carotid sheath.** This is formed by septa from i, ii, and iii, meeting under the sterno-mastoid (fig. 947).

The following **uses and important points** with regard to the anatomy of the deep cervical fascia should be noted:—(A) It **forms certain definitely enclosed spaces** in which pus or growths may form, and by the walls of which these morbid structures may be tied down and thus rendered difficult of diagnosis, while their increasing pressure may embarrass the air-passages, etc. Thus: (1) In the first space, which lies between No. 1 and the skin, the structures met with, the platysma and superficial branches of the cervical plexus, are unimportant. Any abscess here is prone to extend, but superficially. (2) In the second space, between the superficial and middle layers, lies a narrow space containing loose cellular tissue and lymphatic glands. Suppuration here is very common, but usually comes forwards. (3) This is the largest and most important of all. From its contents it has been called the **visceral compartment.** (Stiles.) It is bounded in front by the middle, and behind by the prevertebral layer. Its contents are—larynx, trachea, œsophagus, thyreoid, carotid sheath, glands; and below, brachial plexus, subclavian artery, and abundant loose cellular tissue for the movements of the neck. Suppuration is somewhat rarer here; but either pus or growths, if confined in this space, may have baneful effects, from pressure, or from their tendency to travel behind the sternum. (4) This space, between the prevertebral layer in front and muscles behind, is very limited. Retro-pharyngeal abscess forms here, and the dyspnœa it causes is thus explained. The origin of such abscesses is chiefly twofold, either in one of the highest deep cervical nodes, e. g., from infection of the naso-pharynx (p. 714), or from disease of the upper cervical vertebræ. In the former cases (Stiles, Chiene) the suppuration will be *in front* of the prevertebral fascia, pointing towards the pharynx; in the latter *behind* the above fascia, spreading laterally, behind the carotid sheath. In making his incision, now along the posterior border of the sterno-mastoid, the surgeon should keep close to the transverse processes of the vertebræ, to avoid opening the visceral compartment and infecting the structures in it. (B) The deep cervical fascia gives **sheaths or canals** to certain veins which perforate it, e. g., the external jugular. These are thus kept patent, and a ready passage of blood ensured from the head and neck. Further, this fact accounts for the readiness with which air may enter veins, in operations low down in the neck. The carotid sheath is another and different instance. (C) **It helps to resist atmospheric pressure.** (D) Mr. Hilton's suggestion as to **its action on the pericardium** has already been mentioned.

The lymphatic nodes of the head and neck have already been described (p. 706).

SUPERFICIAL ANATOMY OF THE THORAX

Bony points.—The top of the sternum corresponds (in inspiration) to the fibro-cartilage between the second and third thoracic vertebræ, and is distant about 6·2 cm. (2½ in.) from the spine. If traced downwards, the subcutaneous sternum presents a ridge (angle of Louis) opposite to the junction of the manubrium and body, and the second costal cartilages on either side; this ridge corresponds to the fifth thoracic vertebra. At its lower extremity the xiphoid cartilage usually retires from the surface, presenting the depression of the scrobiculus cordis, or 'pit of the stomach.' This is opposite to the seventh costal cartilages and the expanded upper end of the recti, and corresponds to the ninth thoracic vertebra behind.

Parts behind manubrium.—There is little or no lung behind the first bone of the sternum, the space being occupied by the trachea and large vessels, as follows:—The left innominate vein crosses behind the sternum just below its upper border. Next come the great primary branches of the aortic arch. Deeper still is the trachea, dividing into its two bronchi opposite to the junction of the first and second bones of the sternum. Deepest of all is the œsophagus. About 25 cm. (1 in.) from the upper border of the sternum is the highest part of the aortic arch, lying on the bifurcation of the trachea. (Holden.)

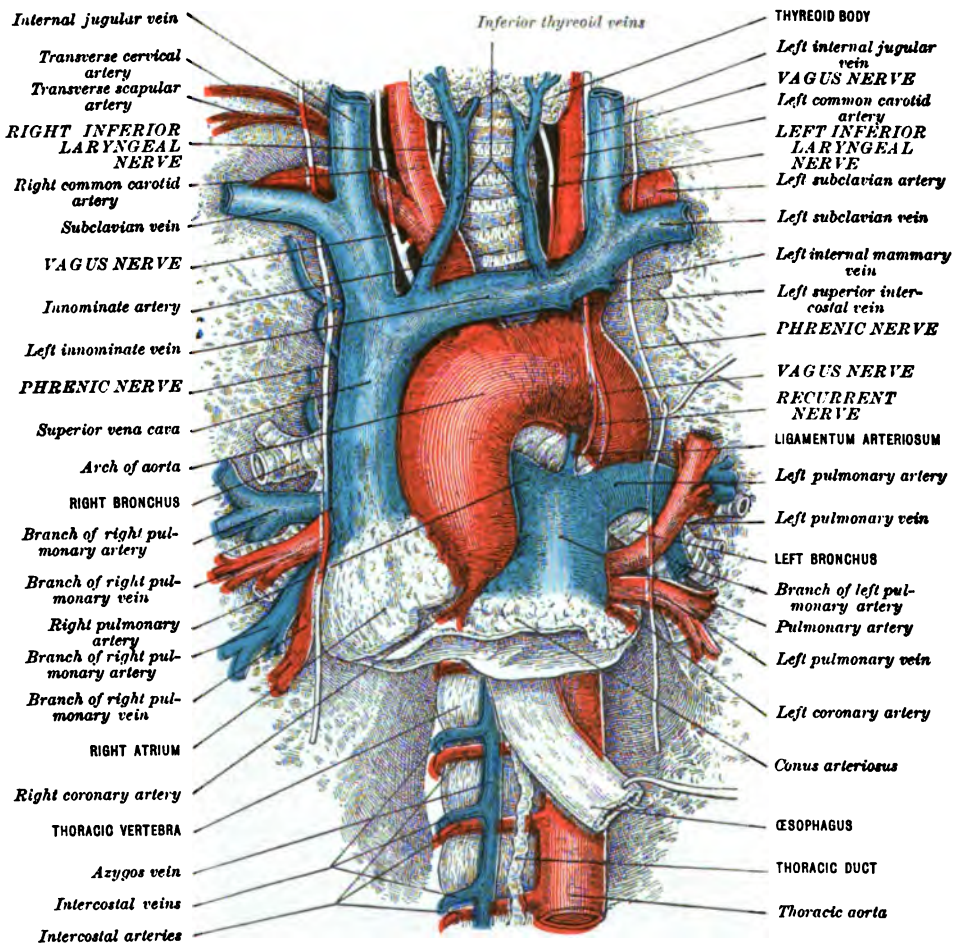
Sterno-clavicular joint.—The expanded end of the clavicle and the lack of proportion between this and the sternal facet, on which largely depends the mobility of this, the only joint that ties the upper extremity closely to the trunk, can be easily made out through the skin. Its strength, considerable when the rarity of dislocation compared with fracture of the clavicle is considered, depends mainly on its ligaments, the buffer-bond meniscus, the costo-clavicular ligament, which checks excessive upward and backward movements, and the fact that the elastic support of the first rib comes into play in strong depression of the shoulder, as in carrying a weight. Behind the joint lie, on the right side, the innominate artery, right innominate vein, and pleura; on the left, the left innominate vein, the left carotid, and the pleura.

Acromio-clavicular joint.—On tracing the clavicle outwards, it is found to rise somewhat to its articulation with the acromion. This joint has very little mobility, and owes its protection to the strong conoid and trapezoid ligaments hard by. Owing to the way in which the joint-surfaces are bevelled, that of the clavicle looking obliquely downwards, and resting upon the acromion, it is an upward displacement of the clavicle which usually takes place.

Ribs.—In counting these, the position of the second is denoted by the transverse line at the junction of the manubrium and body of the sternum. The nipple,

FIG. 948.—THE ARCH OF THE AORTA, WITH THE PULMONARY ARTERY AND CHIEF BRANCHES OF THE AORTA.

(Modified from a dissection in St. Bartholomew's Hospital Museum.)



in the male, lies between the fourth and fifth, nearly an inch outside their cartilages. The lower border of the great pectoral corresponds to the fifth rib. The seventh, the longest of the ribs, is the last to articulate with the sternum. When the arm is raised, the first three digitations seen of the serratus anterior correspond to the fifth, sixth, and seventh ribs. The ninth rib is the most oblique. The eleventh and twelfth can be felt outside the sacro-spinalis. Owing to the obliquity of the ribs, their sternal ends are on a much lower level than their vertebral extremities. 'Thus the first rib in front corresponds to the fourth rib behind, the second to the sixth, the third to the seventh, the fourth to the eighth, the fifth to the ninth, the sixth to the tenth, and the seventh to the eleventh. If a horizontal line be drawn

round the body from before backwards, at the level of the inferior angle of the scapula, while the arms are at the sides, the line would cut the sternum in front between the fourth and fifth ribs, the fifth rib at the nipple line, and the ninth rib at the vertebral column.' (Treves.) The most frequently broken are the sixth, seventh, and eighth. The upper four and the two lowest ribs are best covered by soft parts, and, in the case of the former, the shoulder and arm take off some of the violence that would otherwise reach them. The way in which the ribs are embedded in the soft parts (fig. 749), and the fact that the fragments are often held in place by the periosteum, account for the difficulty which is often met with in detecting crepitus. The intercostal spaces are wider in front than behind. The three upper are the widest of all.

Structures found in an intercostal space.—(1) Skin; (2) superficial fascia, with cutaneous vessels and nerves; (3) deep fascia; (4) external intercostal; (5) cellular interval between intercostals, containing trunks of intercostal vessels and nerves; (6) internal intercostals; (7) thin layer of fascia; (8) subpleural connective tissue; (9) pleura (fig. 749). The intercostal arteries are nine aortic and two from the superior intercostal. An aortic intercostal having given off its dorsal branch, lying beneath the pleura, crosses the space obliquely upwards to gain the lower border of the rib above, enters the costal groove at the angle, and runs forwards between the intercostal muscles to anastomose with the anterior intercostals from the internal mammary or musculo-phrenic. Hence the rule of making the incision in empyema above the upper margin of the lower rib. Along the dorsal branch a vertebral abscess may track backwards.

Internal mammary artery.—This descends behind the clavicle, the costal cartilages, and the first six spaces, about 1·2 cm. (½ in.) from the edge of the sternum. In the sixth intercostal space it divides into musculo-phrenic and superior epigastric arteries. Its venæ comites uniting join the innominate vein of the same side. A punctured wound of the artery is most easily secured in the second and third spaces; below, resection of part of a costal cartilage will be needed.

Structures passing through the upper aperture of the thorax.—If a horizontal section is made passing through the manubrium sterni, upper border of the first rib, and upper part of the first thoracic vertebra, the following structures are met with:—(1) **In the middle line.** Sterno-hyoid and sterno-thyreoid muscles, with their sheaths of deep cervical fascia, cellular tissue in which are the remains of the thymus gland, the inferior thyreoid veins, the trachea and tracheal fascia, the œsophagus, and longus colli muscles. Between the trachea and œsophagus are the recurrent nerves. (2) **On each side.** The apex of the lung, covered by pleura, deep cervical fascia, and Sibson's fascia from the scalenes, rises about 3·7 cm. (1½ in.) above the first rib. Between it and the trachea and œsophagus lie the following: the internal mammary artery, the phrenic nerve; on the right side, the innominate vein and artery, with the vagus between the two, the cardiac nerves, and the right lymphatic duct. On the left side are the common carotid and subclavian arteries, with the left vagus between them, the cardiac nerves and the thoracic duct. Farthest back and on each side are the trunk of the sympathetic, the superior intercostal artery, and the first thoracic nerve.

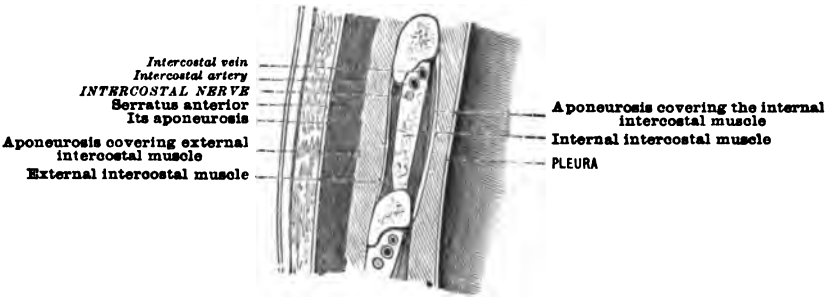
The mamma.—This lies chiefly on the pectoralis major and slightly on the rectus abdominis and serratus anterior. It is usually described as reaching from the second or third to the fifth or sixth rib, and from the sternum to the anterior border of the axilla. It is most important to remember that the breast is often a much more extensive structure than would be included in the above very limited description. Thus—(1) the gland is not encapsuled at its periphery, its tissue branching and breaking up here to become continuous with the superficial fascia. (Stiles.) (2) The retinacula cutis contain lymphatics and, sometimes, mammary tissue. (3) There is a lymphatic plexus, and, often, minute lobules of gland tissue, in the pectoral fascia. (Heidenhain.) Fully one-third of the whole mamma lies anterior and external to the axillary border of the pectoralis major. (Stiles.) That part of the upper and outer quadrant known as the axillary lobe is of especial importance from its reaching into close vicinity with the anterior pectoral group of axillary nodes (p. 717). In the male the nipple is placed in the fourth space, nearly 2·5 cm. (1 in.) outside the cartilages of the fourth and fifth ribs. On the nipple itself open the fifteen or twenty ducts which dilate beneath it, and then diverge and break up for the supply of the lobules. The skin over the areola is very adherent, pigmented,

and fatless. Here also are groups of little swellings corresponding to large sebaceous follicles and areolar glands. The skin over the breast is freely movable, and united to the fascia which encases the organ, and thus to the interlobular connective tissue, by bands of the same structure—the retinacula cutis. Under the breast, and giving it its mobility, is a cellulo-fatty layer, the seat of submammary abscess. The **nerves** which supply the breast are the anterior cutaneous branches of the second, third, fourth, and fifth intercostal nerves, and the lateral branches of the last three. The connection of these trunks serves to explain the diffusion of the pain often observed in painful affections of the breast. Thus pain may be referred to the side of the chest and back (along the above intercostal trunks), over the scapula, along the inner side of the arm (along the intercosto-brachial nerve), or up into the neck. The gland is supplied by the following **arteries:** the aortic intercostals of the second, third, fourth, and fifth spaces, similar intercostal branches from the internal mammary, which runs outwards, two small branches to each space, perforating branches from the same vessel, one or two given off opposite to each space, the long thoracic and external mammary (when present) from the axillary.

The lymphatics have already been described (p. 719).

In **removal of the breast** elliptical incisions will usually suffice if employed on wide lines, and if attention be paid to the following points:—(1) Those details in the surgical anatomy already referred to, especially those bearing on the extensiveness of this organ, and the proportionate difference between seen and unseen disease. (2) The importance of removing in one continuous piece the whole breast, all the skin over it, the costo-sternal part of the great pectoral,

FIG. 949.—SECTION OF THE SIXTH LEFT INTERCOSTAL SPACE, AT THE JUNCTION OF THE ANTERIOR AND POSTERIOR THIRDS. (Tillaux.)

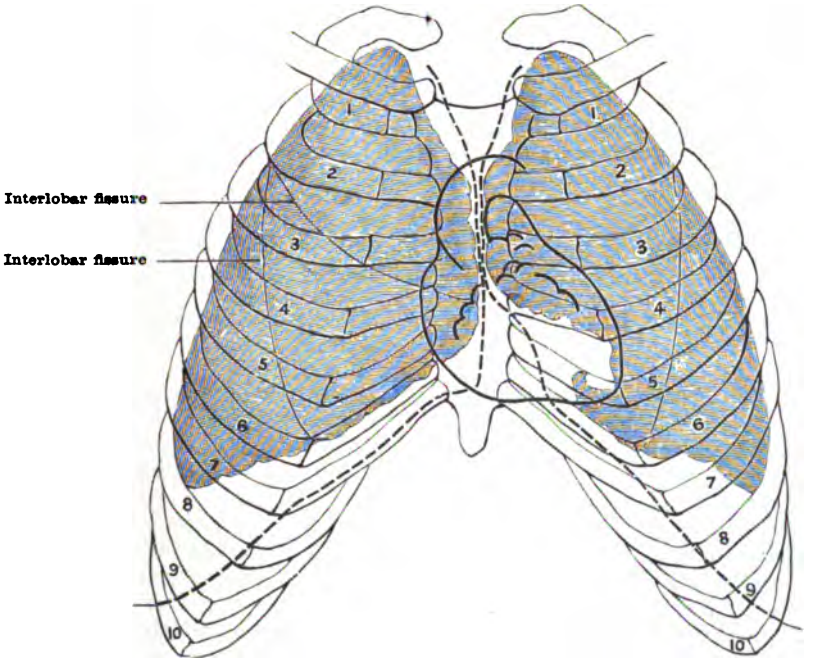


the axillary fat, and lymphatics. The lower elliptical incision will start from the apex of the axilla below the anterior fold, sink below the seventh rib in the mid-axillary line, and thence running below the lower margin of the heart, curve upwards to the sternum. The upper incision, curved upwards, will join the two extremities of the first, passing over the second rib, above the upper limit of the breast. The greatest width of the wound should always be opposite to the most tangible part of the disease.

Outline of the lungs. Their relation to the chest-wall.—The apex of the lung rises about 3·7 cm. (1½ in.) (from 1·2 to 4·3 cm.) above the first rib into the base of the posterior triangle lying behind the inner end of the clavicle, the sterno-mastoid, and the anterior scalene, covered by the pleura, deep cervical fascia, and Sibson's fascia, derived from the group of scalenes, and having the subclavian artery arching over it. From the apices the thin anterior borders converge inwards behind the sterno-clavicular joints and the first piece of the sternum, to the junction of this with the second, almost meeting at this point. Thence the two borders descend parallel and close to each other (the left sac overlapping the right slightly), and thus covering over the upper part of the heart and the large vessels, to a point midway between the fourth pair of costal cartilages, where they diverge, but not to an equal degree. The right descends in an almost straight line as far as the sixth chondro-sternal joint. The left is deeply notched (incisura cardiaca, see below). The lower borders of the lung pass downwards and outwards across the sides of the chest from the sixth chondro-sternal joint to the tenth thoracic spine, along the lines given below. In the nipple-line the lung reaches the sixth rib, in the posterior fold of the axilla, the eighth, and opposite the angle of the scapula (the arms being close to the sides), the tenth rib. Thus, to map out the lung, a line should be drawn from

the apex, a point about 3·7 cm. (1½ in.) above the first rib, or 2·5 cm. (1 in.) above the clavicle, a little outside the sterno-mastoid muscle, at the junction of inner and middle thirds of clavicle, obliquely inwards, behind the sterno-clavicular joint, to near the centre of the junction of the first and second bones of the sternum. Thence, on each side, a line should be drawn slightly convex as far as a similar point on the sternum lying opposite the articulation of the fourth chondro-sternal joint. On the right side the line may be dropped as low as the sixth chondro-sternal joint; on the left the incisura cardiaca may be shown by drawing a vertical line along the middle line of the sternum, from the level of the inner extremities of the fourth costal cartilages to the lower end of the gladiolus, and by carrying two other lines, from the extremities of the first line, outwards so as to meet at a point over the heart's apex (Cunningham); to mark this gap, a line should be drawn sloping outwards and downwards from the fourth chondro-sternal articulation across the fourth and fifth interspaces, to a point about 3·7 cm. (1½ in.) below the left nipple (male) and 2·5 cm. (1 in.) to its inner side. This point, lying in the fifth space, marks the apex of the heart. Thence the line curves inwards to the sixth costal cartilage, a little

FIG. 950.—OUTLINE OF THE HEART, ITS VALVES, THE LUNGS (SHADED), AND THE PLEURA. (Holden.)



internal to its chondro-sternal junction, and in the lateral vertical line, i. e., the mid-Poupart's line prolonged upwards. Thus the lower part of the anterior surface of the right ventricle is not covered by lung. The lower border of the lung will be marked on the right side by a line drawn from the sixth chondro-sternal articulation across the side of the chest down to the tenth thoracic spine. The lower border of the left lung will follow a similar line, starting on a level with a similar joint (sixth chondro-sternal joint), but much farther out than on the right side, i. e., in the fifth space, about 7·5 cm. (3 in.) to the left of the middle line, or a point corresponding to the heart's apex. In the nipple-line the lung crosses the sixth rib, in the mid-axillary line the eighth, and opposite the angle of the scapula (the arms being close to the sides), the tenth rib. The position of the great fissure in each lung may be ascertained approximately by drawing a line curving downwards and forwards from the second thoracic spine to the lower border of the lung at the sixth costal cartilage; and the smaller fissure of the right lung extends from the middle of the foregoing to the junction of the fourth costal cartilage with the sternum. It will be seen from the above that there is little lung behind the manubrium. The connective tissue here

between the lung margins contains the thymus, largest at the second year, and, later, its remains. The root of the lung is referred to on p. 1335.

The **pleura,** following much the same line as the lung above and in front, reaches lower down laterally and behind. Thus the two sacs starting from about the inner third of the clavicle, 2·5 to 5 cm. (1 to 2 in.) above the first rib, converge towards the angle of Louis (p. 1291); meeting here, they descend vertically, the left overlapping the right slightly, to the fourth chondro-sternal joint. Hence the *right* sac descends behind the sternum to the sterno-xiphoid junction and sixth chondro-sternal joint. Thence, as it curves to the back of the chest, it crosses the sixth and seventh ribs close to the lateral vertical line (*vide supra*), the eighth in the mid-axillary, the tenth in the line of the angle of the scapula, and thence towards the twelfth rib or eleventh thoracic spine at the outer border of the sacro-spinalis. On the *left* side the pleura parts company from the right at the level of the fourth chondro-sternal junction, deviating outwards and downwards across the fourth and fifth interspaces; it then turns again slightly inwards to meet the sixth costal cartilage. Thus, as in the case of the lung, but to a less extent, there is a small area of the pericardium, and, under it, the right ventricle uncovered by the pleura. Over the side and back of the chest, along its diaphragmatic reflexion, the left pleura reaches a little lower than the right. The *deepest part of the pleural sac* is where the reflection crosses the tenth rib or tenth space in the mid-lateral line, i. e., one drawn vertically downwards midway between the spine and the sternum. From this it ascends slightly as it curves back to the spine. (Cunningham.) *The relations of the pleura to the last rib* are of much importance to the surgeon in operations on the kidney. In the case of a twelfth rib of ordinary length, the pleural reflexion crosses it at the outer border of the sacro-spinalis; when a rudimentary last rib does not reach the outer border of this muscle, an incision carried upwards into the angle between the eleventh rib and the sacro-spinalis will open the pleural sac. (Melsome.)

For tapping the pleura there are two chief **sites**:—(1) The sixth or seventh space in front of the posterior fold of the axilla. (2) The eighth space behind, in the line of the angle of the scapula. For **the incision of an empyema** the first is usually chosen. The overlying soft parts are not thick, the interspace is wide enough, drainage is sufficient (especially if part of the seventh or eighth rib be resected), and this site is free from the objection that the angle of the scapula overlaps the seventh and eighth ribs, unless the arm is raised.

Outline of the heart. Its relation to the chest-wall.—The upper limit of the heart (base) will be defined by a line crossing the sternum a little above the upper border of the third costal cartilage, reaching about 1·2 cm. (½ in.) to the right and about 2·5 cm. (1 in.) to the left. Its apex corresponds to a point in the fifth space, 3·7 cm. (1½ in.) below the male left nipple, and 2·5 cm. (1 in.) to the inner side. This point will be at 7·5 cm. (3 in.) from the left border of the sternum. The right border (right atrium) will be given by a line, slightly convex outwards, drawn from the right extremity of the upper border to the right seventh chondro-sternal joint. If another line, similarly slightly convex, be drawn onwards from this point across the last piece of the sternum, just above the xiphoid cartilage, to the apex, it will give the lower border (margo acutus of right ventricle), which rests on the central tendon of the diaphragm. The left border (margo obtusus of left ventricle) will be given by a line, convex to the left, passing from the left extremity of the upper border to the apex, well inside the nipple-line. This line should be 7·5 cm. (3 in.) from the middle of the sternum at the level of the fourth costal cartilage. The base of the heart is opposite the four middle thoracic vertebræ, viz., the sixth, seventh, eighth, and ninth. The apex and anterior or costo-sternal surface have been mentioned. The posterior or diaphragmatic surface (chiefly left atrium and left ventricle) rests upon the diaphragm, mainly the central tendon, to which the intervening pericardium is connected, and is thus adjacent to the liver and a small portion of the stomach.

If a circle 5 cm. (2 in.) in diameter be described around a point midway between the left nipple and the lower end of the gladiolus, it will define with sufficient accuracy for practical purposes that part of the heart which lies immediately behind the chest wall, and which is uncovered by lung or pleura. (Latham.)

The valves.—The **pulmonary valves** (the highest and most superficial) lie, in front of the aortic, behind the third left chondro-sternal joint, and opposite to the upper border of the third costal cartilage. The **aortic valves** lie behind and a little

below these, opposite to the inner end of the third intercostal space, and on a level with the lower border of the third left costal cartilage. The **auriculo-ventricular openings** lie at a somewhat lower level than that of the aortic and pulmonary. Thus the **tricuspid valves** lie behind the middle of the sternum at the level of the fourth intercostal space; and the **mitral valves,** the most deeply placed of all, lie a little to the left of these, behind the left edge of the sternum and the fourth left costal cartilage.

'Thus these valves are so situated that the mouth of an ordinary-sized stethoscope will cover a portion of them all, if placed over the juncture of the third intercostal space, on the left side, with the sternum. All are covered by a thin layer of lung; therefore we hear their action better when the breathing is for a moment suspended.' (Holden.)

The pericardium.—This fibro-serous sac, situated in the middle mediastinum, is triangular in shape, with the apex upwards. Here its fibrous layer gives investment to the large vessels, except the inferior cava. It is also continuous with the deep cervical fascia. The base, connected with the diaphragm, has been referred to above (p. 1296). In front a varying area (fig. 950), owing to the divergence of the left pleura, is in contact with the left half of the lower part of the sternum, and more or less of the inner ends of the fourth, fifth, and sixth costal cartilages, here forming the posterior boundary of the anterior mediastinum. Behind, the pericardium is the anterior boundary of the posterior mediastinum, and is in close contact with the œsophagus and aorta.

' **Paracentesis of pericardium.**—While the seat of election must here remain an open question, each case requiring a decision for itself, the one most suitable on the whole is the fifth left space, about 2·5 cm. (1 in.) from the sternum, so as to avoid injury to the internal mammary artery and the pleura, of which the line of reflexion has been shown to vary. About 4·3 cm. (1¾ in.) is an average depth of the chest wall here, the needle being directed at a right angle to the surface of the chest.

In **incision of the pericardium** to establish free drainage, a portion of the fifth or sixth left costal cartilage should be carefully resected, the internal mammary artery tied, the transversus thoracis (triangularis sterni) scratched through, and the pleural reflexion pushed aside.

Relation of vessels to the wall of the thorax.—Aortic arch.—The ascending part reaches from a spot behind the sternum, a little to the left of the centre, on a level with the third left costal cartilage, to the upper border of the second right cartilage; thus it passes upwards, backwards, and to the right, and is about 5 cm. (2 in.) long. The transverse part then crosses backwards to the left behind the sternum (the highest part of the arch being about 2·5 cm. (1 in.) below the notch), reaching from the second right costal cartilage to the lower border of the fourth thoracic vertebra on the left side. This part recedes from the surface, and, with the next, cannot be marked out on the surface. The third, or descending part, the shortest of the three, reaches from the lower border of the fourth to that of the fifth thoracic vertebra.

Fig. 947 will remind the reader of many of the pressure symptoms which may accompany an **aneurysm of the aortic arch**; e. g., pressure on the left innominate vein, the three large arteries, trachea, and left bronchus, recurrent nerve, œsophagus, and thoracic duct. In **aneurysm of the thoracic aorta,** pain, usually unilateral, referred to the corresponding intercostal nerves, is a common pressure symptom.

The pulmonary artery lies behind the left side of the sternum and its junction with the second and third costal cartilages.

Innominate artery.—A line drawn from the top of the arch, about 2·5 cm. (1 in.) below the sternal notch, and close to the centre, to the right sterno-clavicular joint, will give the line of this vessel.

Left common carotid.—This vessel will be denoted by a line somewhat similar to the above, passing from the level of the arch a little to the left of the last starting-point to the left sterno-clavicular joint.

Left subclavian artery.—A line from the end of the transverse arch, behind the left of the sternum, straight upwards to the clavicle, delineates the vertical thoracic course of the long left subclavian artery; its thoracic portion lies behind the left carotid.

Innominate veins.—The **left,** 7·5 cm. (3 in.) long, extends very obliquely from the left sterno-clavicular joint, behind the upper part of the manubrium, to a point

1·2 cm. (½ in.) to the right of the sternum, on the lower border of the first right costal cartilage. The **right,** about 2·5 cm. (1 in.) long, descends almost vertically to the above point from the right sterno-clavicular joint.

Venæ cavæ.—The **superior** descends from the point above given for the meeting of the innominate veins in the first intercostal space, close to the sternum, and perforates the right auricle on a level with the third costal cartilage. The **inferior vena cava.**—The opening of this vein into the right auricle lies under the middle of the fifth right interspace and the adjacent part of the sternum.

The œsophagus.—The relations of this tube in its cervical and thoracic portions are the most important, e. g., to the trachea and left bronchus; the vagi and left recurrent nerve; the pleuræ, left above and right below, aorta, and pericardium. Its lymphatics go below into those of the posterior mediastinum, above into the lower deep cervical (p. 710), a point sometimes diagnostic in malignant disease.

The lumen of the œsophagus is narrowed at three points:—(1) and best marked at the cricoid cartilage, (2) where it is crossed by the left bronchus, (3) as it passes through the diaphragm. The tube, 25 cm. (10 in.) long, extends from the sixth cervical to the lower border of the tenth thoracic vertebra. In an adult, the distance from the incisor teeth to the cricoid is about 15 cm. (6 in.); an additional 7·5 cm. (3 in.) gives the level of the crossing of the left bronchus, while from the teeth to the opening in the diaphragm would be from 35 to 37·5 cm. (14 to 15 in.). To expose the tube in the neck an incision is made on the left side, much as for the higher ligature of the common carotid, but carried lower down. The depressor of the hyoid being drawn inward or divided, the pretracheal fascia is opened, which allows of the overlapping thyreoid and trachea being displaced inwards, while the carotid sheath is retracted outwards. The tracheal rings are the best guide to the œsophagus. The recurrent nerve must be avoided.

THE ABDOMEN

Abdominal lines and planes.—Of these lines, with imaginary planes continued backwards and subdividing the subjacent cavities, the following are the most important:—A. **Vertical**—(1) **Median vertical.** From the middle of the suprasternal notch to the centre of the symphysis pubis. (2) **Mid-Poupart's line.** From the centre of Poupart's ligament to the centre of the clavicle. The upper part of this passes 2·5 cm. (1 in.) to the inner side of the male nipple. As it is drawn upwards it usually touches the tip of the ninth costal cartilage. B. **Horizontal**—(1) **Intertubercular.** Passing through the tubercles or highest point of the iliac crests, situated about 5 cm. (2 in.) behind the anterior superior spines and the body of the fifth lumbar vertebra. (2) **Infra-costal.** Along lower margins of the tenth costal cartilages and crossing the body of third lumbar vertebra. (3) **Transpyloric** (Addison). Half-way between both the suprasternal notch and the symphysis pubis, and also between the sterno-xiphoid junction and the umbilicus, this line crosses the body of the first lumbar vertebra. It crosses the pylorus very frequently, hence its name.

Fig. 969 shows how the abdomen is subdivided by the above given lines and planes. The contents of the regions are given at p. 1098. Some practical points in the abdominal wall are referred to in the account of INGUINAL HERNIA (p. 1319).

Skin markings: bony and muscular landmarks.—The **linea alba,** or meeting of the aponeuroses of the great abdominal muscles over, under, and between the recti, reaches from the apex of the xiphoid cartilage to the symphysis. It is best marked above the umbilicus. Below, on the other hand, the recti are in close apposition, one of them being usually exposed in an incision here. Its little vascularity and comparative thinness fit this line as the seat of election for many of the operations on the abdominal cavity: they also explain the weakness of the after-union. In the linea alba, a little below its centre, is the umbilicus. This corresponds to the level of the fibro-cartilage between the third and fourth lumbar vertebræ, the tip of the third lumbar spine (Windle), a point usually 2·5 cm. (1 in.) above the intertubercular plane, and 1·8 to 2·5 cm. (¾ to 1 in.) above the bifurcation of the aorta. It is not constant in exact position.

On each side of the linea alba, and about 6 to 7 cm. (2½ to 3 in.) from it (according to the muscular development), a line, curved with a slight convexity outwards, the **linea semilunaris,** denotes the point of division of the abdominal aponeuroses,

reaching from the ninth costal cartilage to the pubic spine. Between the linea alba and the linea semilunaris run the three tendinous inscriptions, of which one is placed at the umbilicus, another at the xiphoid cartilage, and a third between the two, on a level with the tenth costal cartilage. There is, rarely, a fourth below the umbilicus. The objections to an incision in the linea semilunaris are that it leaves a weak spot, owing to the gaping of the cut aponeuroses, and that, lower down, several of the nerves to the rectus are divided. An incision between the fibres of the rectus itself is better.

In tapping the bladder above the pubes, the trocar should be introduced immediately above the pubes and driven backwards and a little downwards. In this operation, and in suprapubic cystotomy, the retro-pubic space or **cavum Retzii** is opened. This is bounded in front by the pubes and triangular ligament, behind by the anterior surface of the bladder. Below are the true ligaments of this viscus. The space contains fatty tissue and veins, increasing in size with the advance of life. If about ten ounces of fluid are injected into the bladder, the peritoneum will be raised sufficiently to allow of a three-inch incision being made between the recti and pyramidales immediately above the pubes. The transversalis fascia is thicker below, and is often separated from the linea alba by fat, which must not be mistaken for the extra-peritoneal layer. The peritoneal reflexion is loosely connected to the bladder and can always be peeled upwards.

A transverse line drawn from one anterior superior spine to the other crosses at about the level of the top of the promontory of the sacrum. Such a line will always show whether the pelvis is horizontal or not. (Holden.)

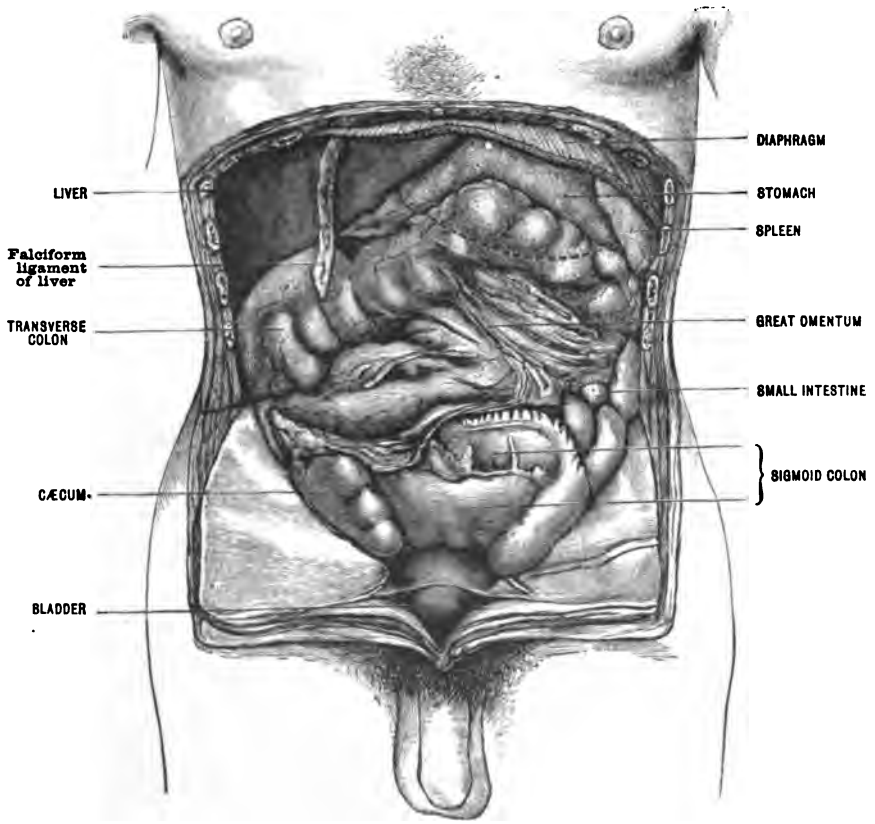
The **inguinal (Poupart's) ligament** corresponds to a line drawn with a slight curve downwards between the anterior superior spine and the pubic spine. The first of these bony prominences corresponds to the starting-point of the above ligament, the attachment of the fascia lata to the ilium, the meeting of the fleshy and aponeurotic parts of the external oblique (denoted by a line drawn upwards from this spine to the ninth costal cartilage, or often a little anteriorly to these points), the point of emergence of the external cutaneous nerve, and part of the origins of the internal oblique, transversus, and tensor fasciæ latæ. The pubic spine marks the outer pillar of the **subcutaneous inguinal (external abdominal) ring,** the mouth of which corresponds to the crest, or that part of the pubes lying between the spine and the symphysis. The neck of an inguinal hernia is above the spine and Poupart's ligament; that of a femoral hernia below and external to the spine, and below the same ligament. The ring, and especially its outer pillar, can easily be felt by invaginating the scrotal skin with a finger, and pushing upwards and outwards. In a female patient, if the thigh be abducted, the tense tendon of the adductor longus will lead up to the site of the ring. The **abdominal inguinal (internal abdominal) ring** is situated about 1·2 cm. (½ in.) above the centre of Poupart's ligament; oval in shape, and nearly vertical in direction, it has the arching fibres of the transversus above it, and to its inner side the inferior epigastric artery, lying behind the spermatic cord. The pulsations of this vessel here guide the finger in the insertion of the uppermost deep sutures in radical cure of hernia. The **canal** runs obliquely downwards and forwards between the two rings. In the adult it is about 3·7 cm. (1½ in.) long, but in early life, and in adults with a large hernia dragging upon the parts, the two rings are much nearer, and may be one behind the other. If the external ring be exposed, and the finger thrust carefully up the canal, the following structures will be noted:—After the finger has carefully dilated the canal, its tip will be prevented from entering the abdomen by the infundibuliform fascia. If it be pressed downwards, it will feel Poupart's ligament, which, with the meeting of the fascia transversalis, forms the floor; above, it will be arrested by the arching fibres of the internal oblique and transversus, coming down to the terminal (pectineal) line to form the falx inguinalis (conjoined tendon). Towards the abdominal wall the finger will feel the aponeurosis of the external oblique stretching over the whole anterior aspect of the canal; if turned towards the belly cavity, the finger would feel less resistant layers, viz., extra-peritoneal fat and peritoneum, and behind the external ring, the conjoined tendon. The finger would, of course, also take notice of the spermatic cord in the male and the round ligament in the female, and investigate any alteration in the former, and isolate the vas deferens.

Vessels in the abdominal wall.—The three superficial branches of the common femoral, the external pudic (superior and inferior), epigastric, and circumflex iliac, supply the lower part of the abdominal wall and the adjacent groin and genitals. The others that have to be remembered are the inferior epigastrics and the

epigastric branch of the internal mammary, the deep circumflex iliacs, the last two intercostals, and the abdominal branches of the lumbar arteries. Of these, the inferior epigastric is the most important; its course will be marked out by a line drawn from a point just internal to the centre of the inguinal (Poupart's) ligament, upwards and inwards to the inner side of the internal ring, and thence to a point about midway between the pubes and umbilicus, forming the outer boundary of Hesselbach's triangle (fig. 964). Here the vessel, which at first lies between the peritoneum and fascia transversalis, perforates the latter and, passing over the fold of Douglas, enters the sheath of the rectus. It then runs upwards, closely applied to the back of that muscle, and, a little above the level of the umbilicus, divides into branches which anastomose with the epigastric branch of the internal mammary.

One **superficial vein in the abdominal wall** needs especial mention, the thoracoepigastric, joining the veins of the chest, e. g., the long thoracic, above with the superficial epigastric below. Its valves directing the blood downwards below and upwards above (Stiles) may be rendered incompetent when this vessel is enlarged, as in interference with the portal vein, with which it communicates by a vein in the round ligament, or in blocking of the inferior vena cava.

FIG. 951.—THE VISCERA AS SEEN ON FULLY OPENING THE ABDOMEN WITHOUT DISARRANGEMENT OF THE INTERNAL PARTS. (After Sarazin.)



Lymphatics.—It is sufficiently correct to say here that those above the umbilical line go to the axillary, and those below that line to the inguinal nodes.

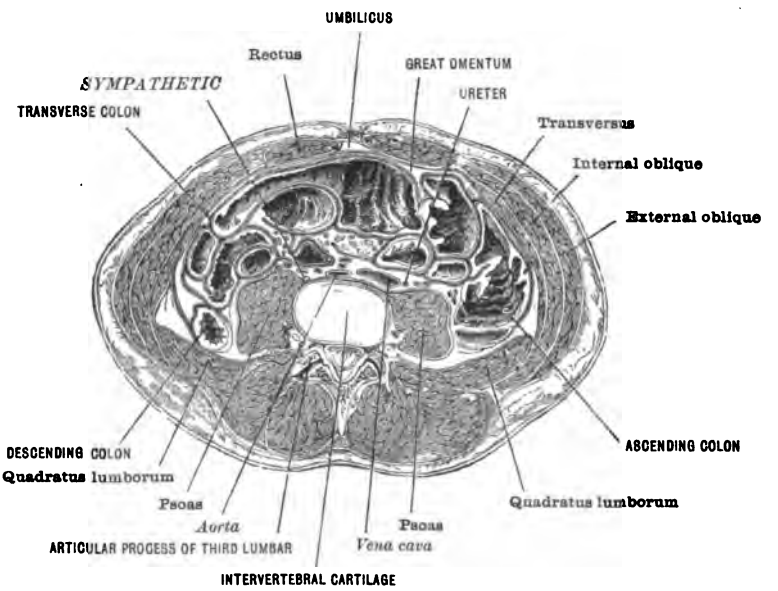
Nerves.—The lower seven intercostals and the ilio-hypogastric and ilio-inguinal supply the abdominal wall. The sixth and seventh intercostals supply the skin over 'the pit of the stomach'; the eighth, the area of the middle linea transversa; the tenth, that of the umbilicus; the last thoracic, ilio-inguinal, and ilio-hypogastric, the region above Poupart's ligament, and that of the pubes. The ilio-hypogastric supplies the skin over the subcutaneous inguinal (external abdominal) ring; the ilio-inguinal that over the cord and scrotum. The last thoracic and ilio-hypogastric cross the iliac crest to supply the skin of the buttock.

Viscera and visceral regions.—The general form of the abdominal space, and the relations of the several organs, before they are disturbed from their normal positions, are given on p. 1098. The arbitrary regions into which the abdomen is usually divided are described on p. 1098.

The diaphragm.—The upper limit of the diaphragm rises to the following levels: Its central tendon to about the lower end of the sternum, or the seventh chondrosternal joint; the right half to the upper margin of the fifth rib, or fourth space, or about 1 cm. (½ in.) below the nipple; the left half not rising quite so high, i. e., to the fifth space, or 2·5 cm. (1 in.) below the nipple.

Viscera behind the linea alba.—From above downwards there are the following (fig. 951):—(1) **Above the umbilicus**—the left lobe of the liver, the stomach, the transverse colon, part of the great omentum, the pancreas, and cœliac (solar) plexus. (2) **Below the umbilicus**—the rest of the great omentum, covering in the small intestines and their mesentery. In the child, the bladder occupies a partly abdominal position; and in the adult, the same viscus, if distended, may rise out of the pelvis and displace the above structures, raising the peritoneum until, if distended half way to the umbilicus, there is an area of nearly 5 cm. (2 in.) safe for operations above the symphysis. The gravid uterus also rises along the linea alba.

FIG. 952.—SECTION OF ABDOMEN BETWEEN THE THIRD AND FOURTH LUMBAR VERTEBRÆ. (Braune.)



Peritoneum.—The reflexions of this are given at p. 1092. The following are amongst its **points of surgical importance**: (1) It is a large lymph sac, complicated by its folds and processes; thus it plays an important part in absorption, exudation, and in the admirable packing of the abdominal contents. Under this heading it must be remembered that wherever chinks exist between the viscera it sends a process, and, at the same time, a path for infection. (2) With reference to perforation and operations it is of interest to recall those viscera in which the peritoneal covering is incomplete or absent. The first includes the second and third parts of the duodenum, the ascending and descending colon, the middle portion of the rectum and the posterior wall of the vagina. The viscera entirely uncovered are the anterior (or inferior) surface and neck and base of the bladder, the anal canal, the anterior wall of the vagina. The following *spaces are of especial importance with reference to drainage and cleansing of the peritoneum.* (1) Douglas's pouch: Here, also, the possible presence of a damaged coil of small intestine, one the seat of a typhoid ulcer or impacted gall-stone, must be remembered. (2) The costo-vertebral and lateral lumbar furrows. (3) The hepato-renal region (Morison), bounded above by the liver, below by the colon and kidney. (4) The subphrenic area.

The liver (figs. 811, 812, and 813).—In the erect position, the anterior thin edge of the liver projects about 1 cm. (½ in.) below the costal cartilages, but can only be made out with difficulty in this position. It may also be displaced downwards by pleuritic effusion or tight lacing. The liver is also, proportionately, much larger in little children.

Of the three more accessible surfaces, *the right lateral* is opposite the seventh to the eleventh intercostal arches, separated from them by the pleura, the thin base of the lung, and the diaphragm. The *superior* surface is accurately fitted with its right and left portions into the hollows of the diaphragm, a slightly depressed area intervening which corresponds to the central tendon. Its level corresponds to that of the diaphragm given above. On the left side, in the adult, the limit of the left lobe will be in the fifth interspace, about 7·5 cm. (3 in.) from the sternum. The *anterior* surface is in contact with the diaphragm, costal arches, and, between them, the ensiform cartilage, and, below, with the abdominal wall. Both the superior and anterior surfaces are subdivided by the falciform ligament, an important point in subphrenic suppuration. In the right hypochondrium the anterior margin corresponds to the lower margin of the thorax; but in the epigastric region, running obliquely across from the ninth right to the eighth left costal cartilage, it crosses the middle line about a hand's breadth below the sterno-xiphoid articulation (Godlee), or half-way between the sterno-xiphoid junction and umbilicus, i. e., in the transpyloric line (p. 1298). Behind, the anterior margin, following the right lateral surface within the costal arches, crosses the last rib towards the level of the eleventh thoracic spine. In the anterior border, a little to the right of the median vertical plane, is the umbilical notch, where the falciform and teres ligaments meet. Still further to the right, and just to the left of the mid-Poupart plane, is the fundus of the gall-bladder. The upper limit of the liver has been given above. Certain structures on the inferior surface must be remembered, especially the **common bile-duct.**

Gall-bladder.—The fundus of this, situated in a fossa on the under surface of the right lobe of the liver, and having the quadrate lobe to its left, lies opposite to the right ninth costal cartilage, close to the outer edge of the rectus. This point corresponds to the site of intersection of the mid-Poupart and transpyloric lines. It is in contact with the hepatic flexure of the colon and the first piece of the duodenum. The cystic duct curves sharply at its exit from the gall-bladder. A distended gall-bladder, as it enlarges, tends to take a line obliquely from the above given point of its emergence towards the umbilicus.

Stomach (figs. 793–796, p. 1100).—This organ, lying in the left hypochondriac and epigastric regions, varies in position more than any other, owing to its mobility, save at the cardiac orifice, and to its varying distension. When empty and contracted, it lies far back in the abdomen, under the left lobe of the liver, and in front of the pancreas. When much distended, its pyloric end moves to the right, and the organ comes forwards, pushing against the liver, close to the lobulus quadratus and gall-bladder, and abdominal wall; and upwards, against the diaphragm, and thus against the heart and left lung. If moderately distended, the cardia will be found under the seventh left chondro-sternal joint, about 2·5 cm. (1 in.) beyond the sternum. Behind, this point corresponds to the tenth thoracic vertebra. The pylorus is very mobile, but a spot near the inner end of the cartilage of the eighth rib, about 7·5 cm. (3 in.) below the xiphi-sternal joint, will denote it with sufficient accuracy. This spot will be in the transpyloric plane (p. 1298), just to the right of the middle line, and on the level of the first lumbar vertebra. It is on a more superficial plane than the cardia. By joining these two points with lines representing the lesser and greater curvatures, the stomach can be marked out (figs. 969, 971). The usual inaccuracies committed in delineating the stomach are as follows: The viscus is marked too horizontally—students forget its oblique position. Thus when empty the greater part, three-fourths, is nearly vertical; the pyloric fourth is more horizontal. (Cunningham.) The greater curvature and fundus are not marked high enough on the left side.

The surgical anatomy of the stomach is of especial importance in the case of **perforating ulcers.** These are rare on the posterior surface, from the readiness with which adhesions form, e. g., to the pancreas. If escape of the contents takes place, it is into the lesser sac. The commonest site of the perforation on the anterior surface is towards the upper part and the pyloric end, but they may occur anywhere. The greatest difficulty is presented by those towards the cardia, from its great depth and fixity. A perforation on the posterior surface may be reached—(*a*) through the great omentum; (*b*) by turning up this and the transverse colon, through the transverse meso-colon. The usual complications—(1) Hæmorrhage; (2) suppuration; (3) adhesion, are also readily explained by the anatomy. Of these, suppuration may take the forms chiefly of general peritonitis, one between the liver and stomach, one beneath the stomach, and *one beneath this and the liver* (subphrenic). The fatality of this last, by thoracic infection,

is well known. The contiguity of the pyloric region to the gall-bladder at once explains the presence of adhesions here and their troubles consequent to a gastric ulcer.

The pancreas.—This lies a little obliquely behind the stomach, crossing the aorta, inferior cava, and left kidney, and spine about the junction of the first and second lumbar vertebræ, or 7·5 cm. (3 in.) above the umbilicus (fig. 819, p. 1127, and fig. 971, p. 1334).

Of the three routes bv which the pancreas can be examined—(1) through the lesser omentum, the stomach being pulled down; (2) through the transverse meso-colon, the colon being raised and the small intestines drawn down; (3) through the great omentum, the stomach and transverse colon being drawn apart—the last route gives much the best access. (E. H. Taylor.)

Intestines.—(A) **Small.**—The length of this is, without the duodenum, about 22½ feet (6·75 m.), viz., duodenum, 1; jejunum, 8½; ileum, 13. The only parts of these that can be localised at all definitely are the duodenum and its junction with the jejunum and the ending of the ileum in the cæcum. The first piece of the **duodenum** lies in the epigastric region, usually near the gall-bladder (*vide supra*), reaching from the pylorus upwards, backwards, and to the right. This is the most mobile of the three parts. The second or descending is in relation with the head of the pancreas, and reaches the umbilical region, descending as low as the second or third lumbar vertebra. The third, or oblique, portion passes from the third lumbar vertebra obliquely from right to left across the second, and, ascending, ends in the jejunum on the left side of the spine. This portion of the intestine being firmly secured in place by fibres from the left crus of the diaphragm and the commencement of the mesentery, accounts for rupture of the intestine usually occurring near this spot.

Other practical points about the duodenum are:—The complexity of the duodeno-jejunal flexure is made use of in gastro-enterostomy. The jejunum is found, when the colon and great omentum have been turned up on the left side of the spine, and a spot selected 30 to 45 cm. (12 to 18 in.) from the flexure, when the duodenum is usually met with in the first part, on the anterior surface. The relation of the second part of the duodenum to the inner aspect of the right kidney perhaps explains the gastric symptoms, e. g., vomiting, met with in movable kidney. The three fossæ about the termination of the duodenum, the superior, the inferior, and paraduodenal fossæ, occasionally contain retro-peritoneal hernia. The inferior mesenteric vessels, running behind the peritoneum, may be closely in relation to the necks of these herniæ. Finally, the oblique course of the common bile-duct in the walls of the second part of the duodenum, and the contracted orifice with the little dilatation (ampulla of Vater) just before, all favour the lodgement of a calculus here.

The **contents of the mesentery are of much importance,** viz., fat in varying amount; the ileo-colic and intestinal branches (vasa brevia) of the superior mesenteric vessels, the latter about twelve, and forming three or four arcades; lacteals, and lymphatic nodes, the latter of surgical importance in tubercular and typhoid mischief; the superior mesenteric plexus; lastly, the intestine itself. Here the small triangular gap formed by the divergence of the two layers of the mesentery above the intestine, the base being formed by the muscular coat of the gut, and the need of obliterating this space, a weak spot, in suture of the intestine, must be remembered.

Of the **jejunum** and **ileum** it may be said that, if undistended, the coils of the jejunum occupy rather the left side, and that of the ileum the right side, in addition to the central regions, where the jejunum would be chiefly above, and the ileum below. But as there is no definite limit between the ileum and jejunum, so there is no regular arrangement of their coils. The only reliable practical means of telling the lower from the upper part of the jejuno-ileum is by their relation to the duodeno-jejunal flexure and the ileo-cæcal junction. The last part of the ileum tends to pass over the psoas and external iliac vessels into the true pelvis. If present, a Meckel's diverticulum, the remains of the yolk stalk or communication between the yolk sac and the intestine, would arise from 30 cm. to 1 m. (1 to 3 feet) from the termination of the ileum.

The upper limit of the **mesentery** would be marked by a spot about 7·5 cm. (3 in.) above the umbilicus, a little to the left of the centre of the body of the second lumbar vertebra, and a little below the transpyloric line. From this point its line extends, curving downwards and outwards, to the right iliac fossa, where it ends in the ileo-cæcal junction, the surface-point being that where the intertubercular and right mid-Poupart's lines intersect each other. The average length of this attached border is about 20 cm. (8 in.).

(B) **Large intestine.**—The **cæcum,** measuring about 6·2 cm. (2½ in.) both in its

vertical and transverse diameters, lies in the right iliac region, in front of the ilio-psoas, and should be so mapped out behind the anterior abdominal wall as to lie above the outer half of Poupart's ligament. Its lowest point would be below the level of the intertubercular plane. It is entirely covered by peritoneum, continuous with the right meso-colon, when this is present. Not infrequently it lies more external, still in the right iliac region, but entirely on the iliacus. In this case flexion of the hip-joint may be interfered with when the appendix is inflamed. The **ileo-cæcal valve,** or junction of the small and large intestines, corresponds to the point where the intertubercular and mid-Poupart's lines intersect each other. The base and orifice of the **vermiform appendix,** which usually comes off 2·5 cm. (1 in.) below the valve on the posterior wall of the cæcum, would be represented by the above point with sufficient accuracy. The appendix itself, averaging 10 cm. (4 in.) in length, of the size of a goose-quill, and often curved, owing to the shortness of its mesenteriole, may project behind the cæcum, ileum, and mesentery, in the direction of the spleen (Treves), or downwards to the left, so as to approach or descend below the brim of the pelvis. This relation is frequent and of great importance. If adherent here, the difficulties and dangers of the operation are much increased. Its presence may now be suspected by a rectal examination. If now adherent to the ovary or bladder, other complications will arise, and micturition may be painful.

The structure of the appendix is full of surgical lessons. (1) *The mucous coat:* This, the chief safeguard from bacterial infection, consists of a single layer, easily destroyed. When destroyed, not only are the lymphatics liable to be opened up, but the mucous coat is readily brought into direct communication with the serous (*vide infra*). The mucous and (2) *sub-mucous coats* are rich in lymphatic tissue, easily inflamed, and readily perishing. (3) The two *muscular coats*, longitudinal and circular, are incomplete in places: through these gaps infection from the mucous may easily reach the serous coat. (Lockwood.) (4) The **serous:** This is sometimes too short to reach the tip of the appendix, leading to the familiar curled or twisted appearance. *Mesenteriole of appendix.* This starts above, at its base, in the mesentery to the ileum. Just below the ileo-cæcal fossa it presents two borders below, one free, one attached to the appendix. Between its folds runs the appendicular artery from the ileo-cæcal. The supply to the tip is the most precarious. (Lockwood.) The following fossæ (Lockwood and Rolleston), especially the last two, may be occupied by the appendix, and when this is shut off by adhesions, may cause much difficulty in finding it. (1) *Ileo-colic.* Above the ileum, between it and the colon. (2) *Ileo-cæcal.* Below the ileum, at the ileo-cæcal angle. (3) *Subcæcal.* Seen when the cæcum is raised. This fossa, being closely related to the iliacus, may, if the seat of an inflamed appendix, interfere with flexion of the thigh.

Incisions for reaching the appendix.—While where pus is present free access and good drainage are paramount, there are two routes for choice: (i) An oblique incision, 5 to 7·5 cm. (2 to 3 in.) long, crossing MacBurney's line (drawn from the anterior-superior spine to the umbilicus) 5 cm. (2 in.) above the iliac spine, and with its centre about 2·5 cm. (1 in.) behind this line. The external oblique (chiefly its aponeurosis) is divided in the direction of its fibres, and then, its edges being well retracted, the next two muscular layers are divided in the direction of their fibres, the incision through the internal oblique being at more or less of a right angle to that in the skin. This incision leaves a good scar, but gives but limited access in a muscular subject or a difficult case. (ii) In the linea semilunaris, after division of the anterior layer of the sheath, the outer border of the rectum is defined and the muscle pulled well inwards, and the peritoneal sac reached by dividing the posterior layer, not the semilunar line itself (p. 1298. Whichever incision is chosen, care should be taken not to divide the deep epigastric artery below **MacBurney's point.** This is situated about 5 cm. (2 in.) above the anterior-superior spine in MacBurney's line. In estimating the value of this point when tenderness is absent here, MacBurney's qualification must be remembered. 'This point, while corresponding to the base of the appendix, does not by any means demonstrate, as one might conclude, that the chief point of disease is there.'

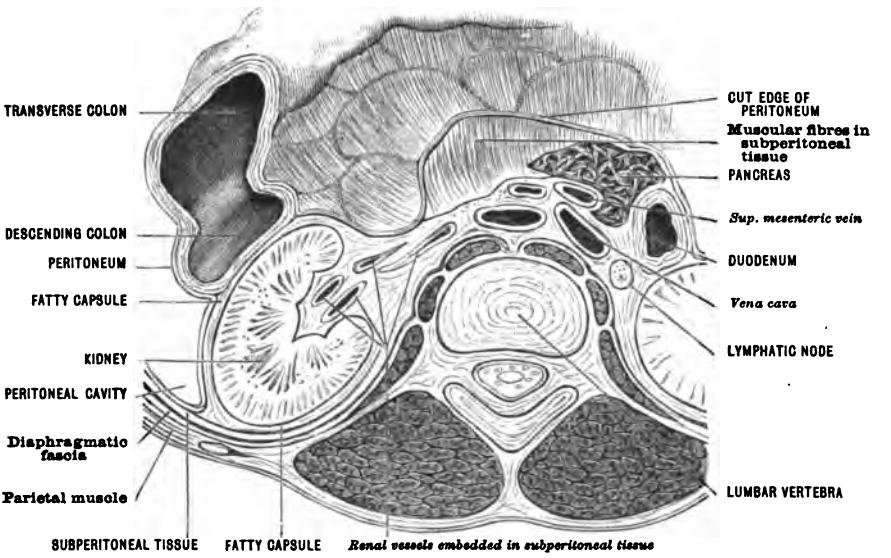
The **ascending colon,** covered, when empty, by small intestine, lies deeply as it passes up over the kidney and the angle between the psoas and quadratus lumborum through the right lumbar region. The hepatic and splenic flexures lie deeply also in the hypochondriac regions, the splenic being higher and more sharply marked than the hepatic, and behind the stomach, while the former is in contact with the under surface of the liver. As a rule, the ascending and descending colons are only covered by peritoneum anteriorly and laterally. In 25 to 30 per cent. a meso-colon is present. On the right side the possibility of adhesions to a diseased kidney must be remembered in operations. Higher up the same may be due to disease of the biliary tract. Here also a gall-stone may ulcerate into the intestine, and cholecystenterostomy be performed. The delay of neglected feces in the cul-de-sac of the cæcum and at the flexures predisposes to catarrh, damage of the epithelium, colitis, and carcinoma. Between the two courses the **transverse colon,** in close contact with the great curvature of the stomach, and varying in position from one, two, or three inches above

the umbilicus, to one nearer or even below this point, according to the degree of its arching downwards. It is the most movable part of the colon. The **descending colon** follows a similar course to the ascending, and ends in the lumbar region at the level of the crest of the ilium in the **iliac colon.** This includes the first part of the sigmoid colon, and extends from the iliac crest to the pelvic brim. It usually has no mesentery. The **pelvic colon** includes the rest of the sigmoid colon and the first part of the rectum and reaches to the third piece of the sacrum. If marked in length and curve it sweeps over to the right side to a varying extent before joining the rectum. This colon has a mesentery. Its varying length, the proximity of its two attached points, viz., inner border of psoas and third sacral vertebra (E. H. Taylor), explain the frequency of volvulus here.

Landmarks for lumbar colotomy.—(1) The lower border and tip of the last rib, which varies in length; (2) a point 1·2 cm. (½ in.) behind the centre of the iliac crest, this point being found by accurate measurement along the crest between the anterior and posterior spines (Allingham); (3) a line drawn vertically upwards from the last-mentioned point to the last rib. This gives with sufficient correctness the line of the outer edge of the quadratus, and the position of a normal colon. On the right side, if the cæcum has failed to descend normally, the colon may be absent, and distended small intestine mistaken for it.

Iliac or anterior colotomy.—The incision here, whether for opening the sigmoid colon or the cæcum, is 2·5, 4. or 7·5 cm. (1, 2½, or 3 in.) long, made parallel with the outer part of Poupart's ligament, and adjacent crest, with its centre 5 cm. (2 in.) above the anterior-superior spine in MacBurney's line (*vide supra*).

FIG. 953.—DIAGRAM SHOWING RELATION OF KIDNEY TO CAPSULE.



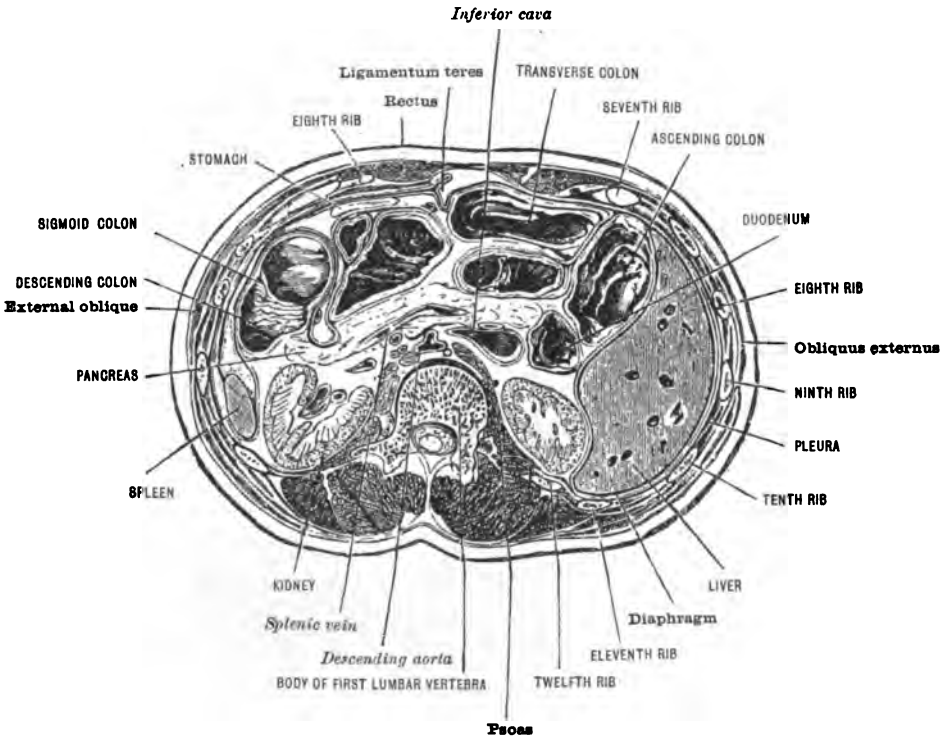
The kidneys.—These lie at the back of the abdominal cavity so deeply in the hypochondriac and epigastric region as to be beyond palpation, unless enlarged or unduly mobile. The lower end of the right being slightly lower than its fellow, encroaches in health upon the lumbar and umbilical regions. These organs lie much higher and nearer to the spine than is usually supposed to be the case, the upper two-thirds of the right and all the left kidney being behind the ribs. Relatively to the vertebræ, the kidneys lie along the sides of the last thoracic and the first three lumbar. To mark them in from the front the following points should be noted: The upper extremity of the right should reach as high up as the seventh costal cartilage, the left up to the sixth, on either side close to the costo-chondral and inter-chondral junctions. This level will correspond to one half way between the sterno-xiphoid and transpyloric lines. The lower end, about 11 cm. (4½ in.) below this point, would be opposite to the subcostal line; that of the right kidney is usually lower, and may encroach upon the umbilical line. For practical purposes the hilus is opposite a point on the anterior abdominal wall, a finger's breadth internal to the tip of the ninth costal cartilage (Stiles), or the junction of the transpyloric and mid-

Poupart's lines. The importance of the relation of the last rib has been mentioned at p. 1296. A vertical line carried up to the costal arch from the centre of Poupart's ligament has one-third of the kidney to its outer side, and two-thirds to its inner side, i. e., between this line and the median line of the body. The shortest distance between the two kidneys, obliquely placed so as to be closer above, 'at the upper part of their mesial borders' (Thane and Godlee), measures about 6·2 cm. (2½ in.).

On the posterior surface of the body the kidney's boundaries are indicated by the following:—(1) A line parallel with, and 2·5 cm. (1 in.) from, the spine, between the lower edge of the tip of the spinous process of the eleventh thoracic and the lower edge of the spinous process of the third lumbar vertebra; (2) and (3) lines drawn from the top and bottom of this line outwards, at right angles to it, for 7 cm. (2¾ in.); (4) a line parallel to the first, and connecting (2) and (3). Within this parallelogram the kidney lies (Morris).

The **chief relations of the kidneys** are:—**Posteriorly**—Quadratus lumborum, psoas, diaphragm, last thoracic, ilio-hypogastric, and ilio-inguinal nerves. The

FIG. 954.—TRANSVERSE SECTION OF THE ABDOMEN THROUGH THE KIDNEYS AND PANCREAS, AT THE LEVEL OF THE FIRST LUMBAR VERTEBRA. (Braune.)



twelfth rib lies behind both, the right, as a rule, not reaching above the upper border. The left often reaches the eleventh rib. **Anteriorly**—The liver, right colic flexure and second part of the duodenum (p. 1103), on the right side. The liver, and stomach above, the body of the pancreas and spleen over the centre, and the descending colon over the lower part of the left kidney.

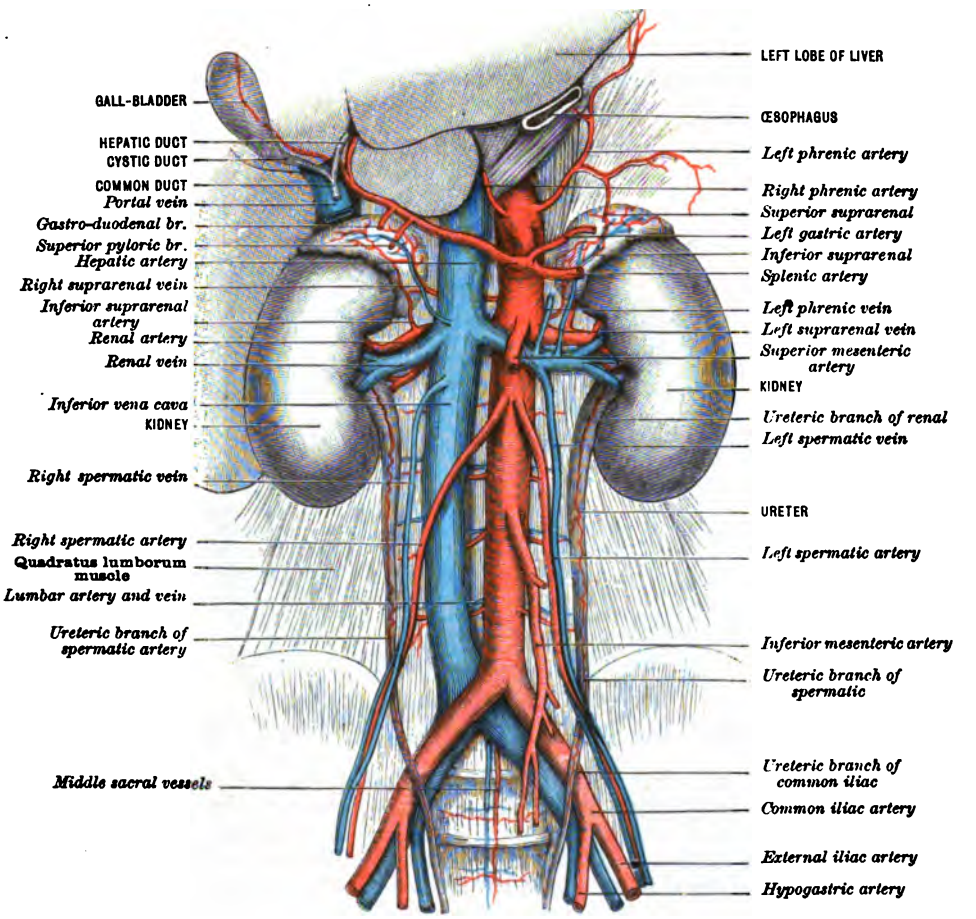
In **the perinephric fat** surrounding the kidney an abscess may pass backwards into the lumbar, or downwards into the iliac regions. The **proper capsule of the kidney** is divided along the convex border of the viscus, in nephrorrhaphy, in Edebohls' decortication, and in some cases of nephrectomy, not of malignant disease, where much difficulty is present. Of **the two main routes for reaching the kidney**—A. The **lumbar** has the advantage of being retro-peritoneal, but involves division of many muscles and in cases of large growths, or where adhesions are present, the access afforded may be limited and deep. The presence of the colon, and on the right side, the cava, is always to be remembered. B. This, the **intra-peritoneal,** gives more room. The chief precaution is to first identify the colon, and incise the posterior parietal peritoneum on its outer side, so as not to endanger its blood-supply.

The ureter.—On an average 30 cm. (12 in.) long, this tube descends almost vertically in its abdominal course on the psoas muscle; it crosses the common iliac at the

level of the intertubercular lines, then passing into the pelvis towards the middle line, it crosses the internal iliac. The proximity of the right ureter to the outer side of the inferior cava must be remembered.

The spleen (figs. 904 and 905).—This lies very obliquely from above downwards, and from within outwards, chiefly in the left hypochondrium, its upper third being in the epigastric region: thus its long axis corresponds closely with the line of the tenth rib. It is placed opposite the ninth, tenth, and eleventh ribs externally, being separated from these by the diaphragm; and internally it is connected with the great end of the stomach. Below, it overlaps slightly the outer border of the left kidney (figs. 954, 971, 972, and 973). Its highest point is on a level with the spine of the ninth thoracic, and its lowest with that of the eleventh thoracic vertebra. Its inner end is distant about 3·7 cm. (1½ in.) from the median plane

FIG. 955.—THE ABDOMINAL AORTA AND INFERIOR VENA CAVA.



of the body, and its outer about reaches the mid-axillary line. (Godlee.) In the natural condition it cannot be felt; but if enlarged, its notched anterior margin extends downwards towards the umbilicus, and is both characteristic and readily felt.

Aorta and iliac arteries.—The aorta enters the abdomen opposite the last thoracic vertebra, a point 12 to 15 cm. (5 to 6 in.) above the umbilicus, or rather above the mid-point between the infrasternal depression and the umbilicus (Thane and Godlee), and thence, lying to the left of the spine, divides into the two common iliacs opposite the disc between the third and fourth lumbar vertebræ, or opposite the body of the fourth lumbar vertebra. This point is about 2·5 cm. (1 in.) below and to the left of the umbilicus, and on a level with a line drawn across the highest part of the iliac crest. A line drawn from this point, with a curve slightly outwards, to just within the centre of Poupart's ligament, will give the line of the iliac arteries; the first 5 cm. (2 in.) (about) giving the average length of the common iliac. The

relation of the common iliac veins is shown in fig. 955. The **right,** much shorter than its fellow, lies at first behind and then somewhat outside its artery. The **left** is at first to the inner side of its artery, and then behind the right. At the upper part of of the fifth lumbar vertebra, behind and outside the right artery, the vena cava begins.

The site of **some of the branches of the aorta** may be thus approximately remembered.

The **cœliac artery** is given off immediately after the aorta has perforated the diaphragm; directly below this is the **superior mesenteric artery.** About 2·5 cm. (1 in.) lower down, or 7·5 cm. (3 in.) above the umbilicus, the **renal arteries** are given off. About 2·5 cm. (1 in.) above the umbilicus would be the level of the **inferior mesenteric artery.** The relation of the above vessels to the transpyloric line (p. 1298) is as follows. (Stiles.) The cœliac artery is two fingers' breadth, the superior mesenteric one, above the line; the renal arteries are a finger's breadth below it. The origin of the inferior mesenteric is midway between the transpyloric and intertubercular lines.

Collateral circulation after ligature of the common iliac.—The chief vessels here are:—

ABOVE.		BELOW.
Internal mammary and lower intercostals	with	Inferior epigastric.
Lumbar	with	Ilio-lumbar and circumflex iliac.
Middle sacral	with	Lateral sacral.
Superior hæmorrhoidal	with	Inferior and middle hæmorrhoidal.

Collateral circulation after ligature of the external iliac:—

Inferior epigastric	with	Internal mammary, lower intercostals, and lumbar.
Deep circumflex iliac	with	Ilio-lumbar, lumbar, and gluteal.
Superior and inferior gluteal (sciatic)	with	Internal and external circumflex.
Inferior gluteal (comes nervi ischiadici)	with	Perforating branches of profunda.
Obturator	with	Circumflex and epigastric.
Internal pudic	with	External pudic.

Collateral circulation after ligature of the internal iliac:—

Inferior gluteal (sciatic)	with	Branches of profunda.
Hæmorrhoidal arteries	with	Inferior mesenteric.
Pubic branch of obturator	with	Vessel of opposite side.
Branches of pudic	with	Branches of opposite side.
Circumflex and perforating of profunda	with	Superior and inferior gluteal (sciatic).
Lateral sacral	with	Middle sacral.
Circumflex iliac	with	Ilio-lumbar and superior gluteal.

THE PERINEUM AND GENITALS

Bony boundaries.—These are the same in either sex. Above and in front is the symphysis pubis, rounded off by the subpubic ligament; diverging downwards and outwards from this point on either side are the rami of the pubes and ischia, ending at the tuberosities of the latter. In the middle line behind is the apex of the coccyx; and reaching from this to the tuberosities are the sacro-tuberous (great sacro-sciatic) ligaments, to be felt by deep pressure, with the lower border of the gluteus maximus overlapping them. The depth of the perineum varies greatly—from 5 to 7·5 cm. (2 to 3 in.) in the posterior and outer part to 2·5 cm. (1 in.) or less in front.

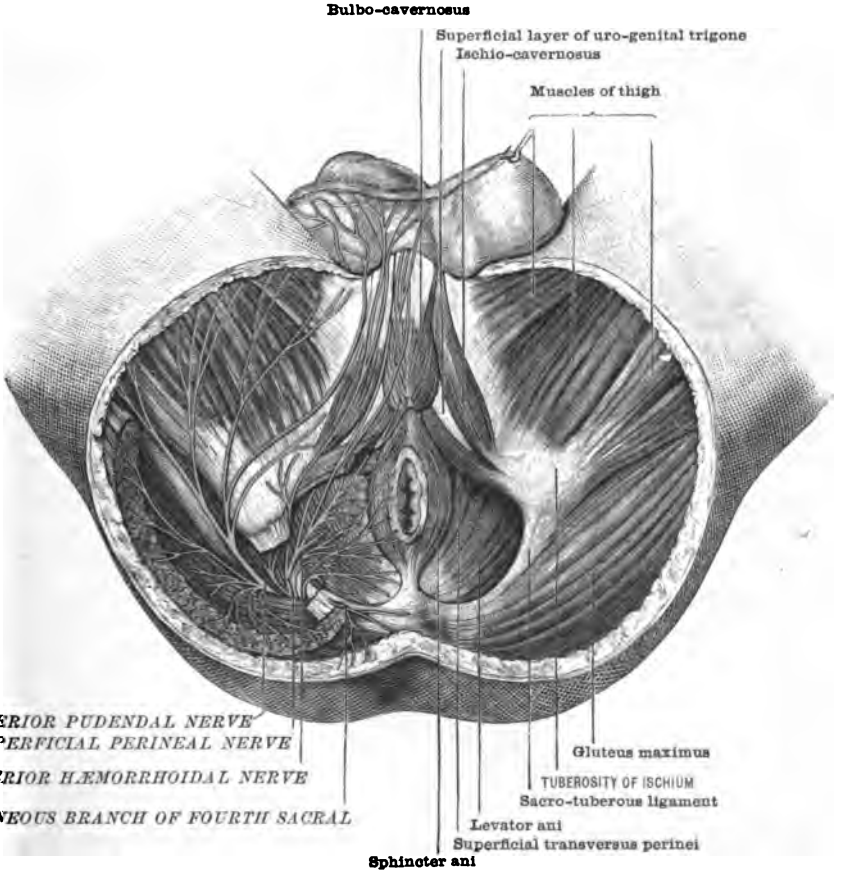
In the middle line, extending longitudinally through the perineum, is the raphe, the guide to the urethra, and 'the line of safety' (on account of the small size of the vessels here) for operations on it.

An imaginary line drawn transversely across the perineum from one tuber ischii to its fellow divides the lozenge-shaped space into **two triangles**—(1) An **anterior,** or **urethro-genital;** and (2) a **posterior,** or **rectal.** The perineum is shut off from the pelvis by a diaphragm formed by the levator ani and coccygeus on each side, with its upper surface covered by the endo-pelvic fascia, and perforated by the urethra, rectum, and vagina.

The **central point of the perineum** is in the adult nearly an inch (25 mm.) in front of the anus, or midway between the centre of the anus and root of the scrotum.

Here the following structures meet, viz., the levator ani, the two transverse perineal muscles, the bulbo-cavernosus, and the sphincter ani. The comparative weakness of the attachment of this muscle in front, i. e., not into a bony point, is important in the division of it, as in operation for fistula. The sphincter should never be cut through anteriorly, especially in women, where its attachment here, blending with the sphincter vaginæ, is a very weak one. This point also corresponds to the centre of the lower margin or base of the uro-genital trigone (triangular ligament). Its development varies much in different bodies. A little in front of this point is the bulb, with the corpus spongiosum passing forwards from it. This would also be the level of the artery of the bulb, so that in lithotomy the incision should always begin below this point. A knife introduced at the central point, and carried backwards and very slightly upwards, should enter the membranous urethra

FIG. 956.—THE MALE PERINEUM. (Modified from Hirschfeld and Leveillé.)



just in front of the prostate, e. g., in median lithotomy and Cock's external urethrotomy. If pushed more deeply, it would enter the neck of the bladder. In **lateral lithotomy** the knife is entered 3·7 cm. (1½ in.) in front of the anus and carried downwards and outwards for 6·2 to 7·5 cm. (2½ to 3 in.) into the ischio-rectal fossa, ending a little below and external to the mid-point between the anus and tuber ischii. This incision begins deeply and ends more superficially. In the deeper part of the incision the knife is carried along the staff through the membranous urethra into the bladder.

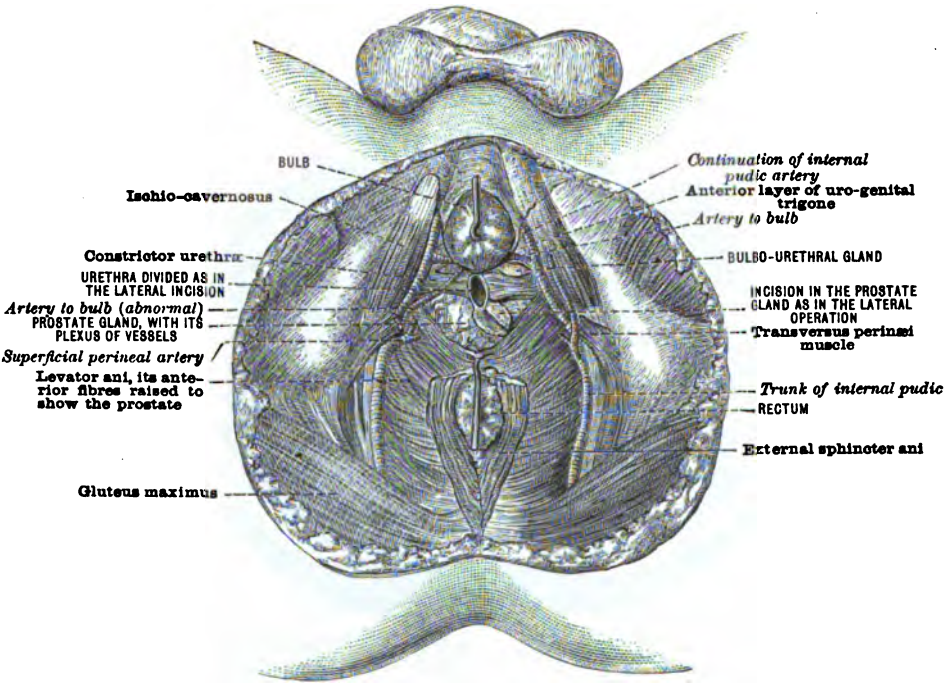
The parts divided in the operation are—skin, superficial fascia (both layers), transverse perineal vessels and nerves, superficial perineal vessels and nerves, inferior hæmorrhoidal vessels and nerves, transversus perinæi muscle, base of uro-genital trigone (anterior layer), membranous urethra and deep muscles, a venous plexus, posterior layer of the uro-genital trigone (triangular ligament), prostatic urethra, and left lobe of prostate and its capsule in part, with some of the fibres of the levator prostatæ.

In median lithotomy, an incision 3·7 cm. (1½ in.) long is made through the central tendinous point and raphe, so as to hit the membranous urethra.

The following structures are divided:—Skin and fasciæ; some of the most anterior fibres of the external sphincter ani; raphe and central tendinous point; minute branches of transverse perineal vessels and nerves; base of uro-genital trigone in centre; membranous urethra and constrictor urethræ.

The attachments and arrangements of the **superficial fascia** (fig. 958) must be traced and remembered. Of the two layers of which it consists, the superficial alone extends over both urethral and rectal triangles alike, and is continuous with the similar structures in adjacent regions, the only difference being that, if traced forwards into the scrotum and penis, it loses its fat, and contains dartos fibres. The deeper layer, found only over the urethral triangle, is called the fascia of Colles (fig. 958). Attached at the sides to the rami of the pubes, behind to the base of

FIG. 957.—DEEP DISSECTION OF MALE PERINEUM. (Roser.)
The bulb is slightly raised and the rectum drawn backwards, in order to make clear the membranous urethra and prostate, which are shown incised as in the lateral operation of lithotomy.


BULB
Ischio-cavernosus
Constrictor urethræ
URETHRA DIVIDED AS IN THE LATERAL INCISION
Artery to bulb (abnormal)
PROSTATE GLAND, WITH ITS PLEXUS OF VESSELS
Superficial perineal artery
Levator ani, its anterior fibres raised to show the prostate
Gluteus maximus
Continuation of internal pudic artery
Anterior layer of uro-genital trigone
Artery to bulb
BULBO-URETHRAL GLAND
INCISION IN THE PROSTATE GLAND AS IN THE LATERAL OPERATION
Transversus perinæi muscle
Trunk of internal pudic
RECTUM
External sphincter ani

the uro-genital trigone, and open in front, it forms the superficial wall of a somewhat triangular pouch, limited behind by the uro-genital trigone, and containing the superficial vessels, nerves, and muscles, the bulb, adjacent part of the urethra, and crura of the penis. Owing to this space being closed behind and open in front, and to its containing the above structures, fluids extravasated within this space will obviously tend to make their way forwards into the scrotum, penis, and lower part of the abdominal wall.

The **urethro-genital triangle** is subdivided into two planes by the uro-genital trigone (triangular ligament) and fascia of Colles. The structures *in the superficial plane*, between the ligament and the fascia of Colles, have been given above. Those in the deeper, i. e., **between the two layers of the trigone,** are—(1) The membranous urethra; (2) the constrictor urethræ; (3) the bulbo-urethral (Cowper's) glands; (4) and (5) part of the pudic artery and nerve; (6) the artery to the bulb; (7) the dorsal vein.

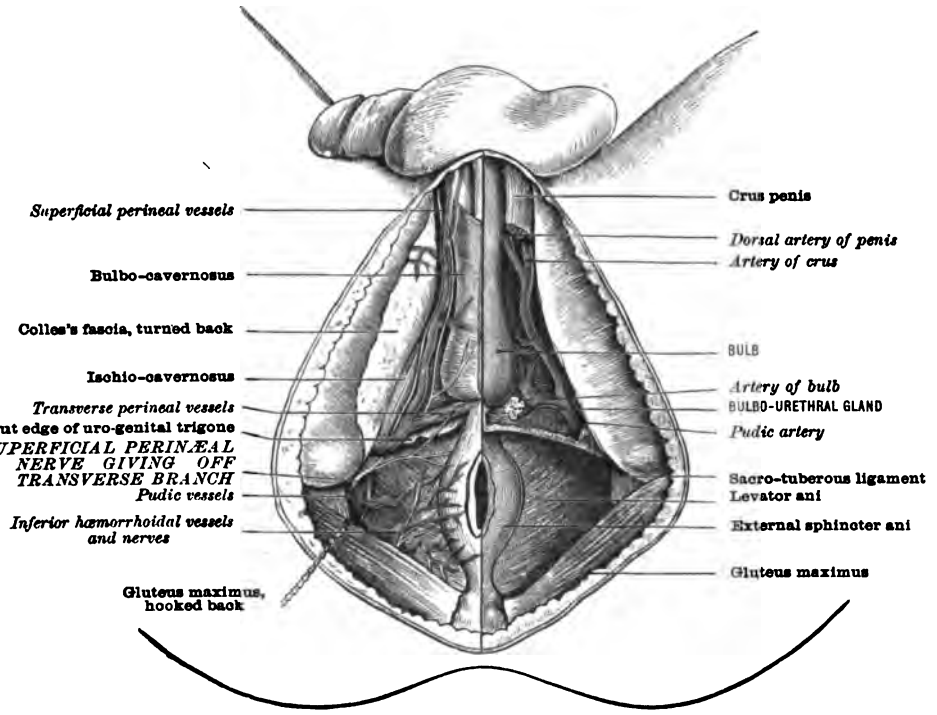
The urethra.—This can be examined in part with the finger, but much better with the aid of a sound. The anterior, or penile, part is movable; the posterior,

or deeper, more fixed. It is narrowest at the meatus and where the membranous urethra passes through the uro-genital trigone. It is widest in the prostatic part and the fossa navicularis. One of the most important landmarks is the uro-genital trigone (triangular ligament), the base of which can just be felt in a thin perineum. The membranous urethra passes through this, about 2 cm. (¾ in.) above the central point of the perineum, about the same distance below the subpubic ligament, or 2·5 cm. (1 in.) below the symphysis. Above the urethra run the dorsal vessels and nerves of the penis.

The fixation, undilatability, surrounding muscular fibres, and close neighbourhood of a large amount of erectile tissue (the bulb), all account for difficulties in introducing instruments past this point. It is here also that the urethra, membranous or bulbous, is most liable to be damaged by a fall or blow. If the bulbous urethra be ruptured, the immediate ecchymosis will be greater; in both cases urine extravasated will be beneath Colles' fascia. In rupture of the membranous urethra urine may either find its way in front of the ligament by coexisting injury to this, or through openings in the ligament for vessels, etc.; in a few cases such urine

FIG. 958.—THE ARTERIES OF THE PERINEUM.

On the right side of the perineum (left side of this figure) Colles's fascia has been turned back to show the superficial vessels. On the left side the superficial vessels have been cut away with the anterior layer of the uro-genital trigone to show the deep vessels.

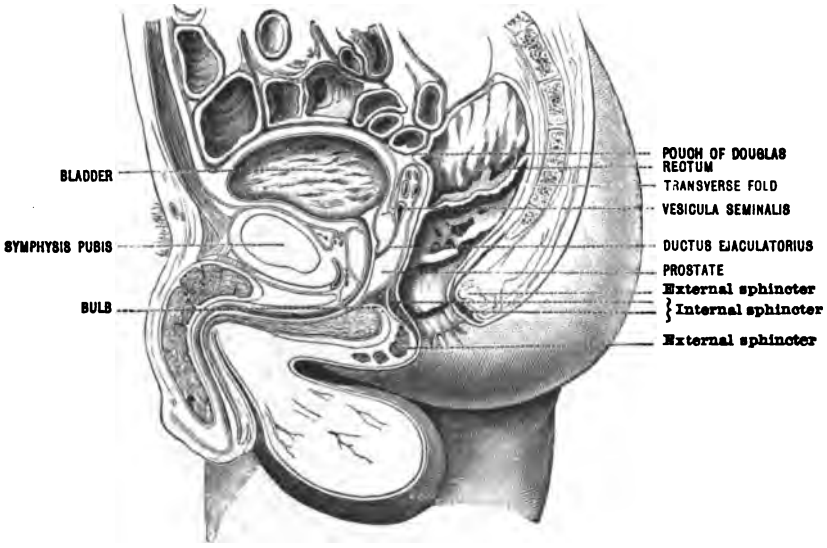


will make its way backwards around the arch of the bladder into the cavum Retzii (p. 1299), ascending thence between the peritoneum and transversalis fascia. The attachment of the deep layer of superficial fascia to the base of the uro-genital trigone accounts for the fact that urine extravasated from a ruptured urethra, or through an opening behind a stricture, passes usually not backwards into the anal triangle, but forwards into the scrotum and abdominal wall. The comparatively horizontal position of the bulbus urethræ (fig. 959) and the large amount of surrounding vascular tissue account for the frequency of gonorrhœal strictures here. The other structures in relation with the uro-genital trigone are shown in fig. 958.

The prostate (figs. 957 and 959).—The relations of this important organ should be studied, whenever possible, with the finger and sound. Roughly comparable to a chestnut in form, size, and dimensions, its base, situated below the neck of the bladder, blends by its muscular tissue with this organ. As the long axis of the prostate is very oblique, the base will be directed upwards and backwards (fig. 959). The apex, resting against the upper or deeper layer of the uro-genital trigone (triangular ligament), lies about 1 cm. (½ in.) behind the subpubic angle. This

part of the organ can be detected by the finger about 4 cm. (½ in.) above the anal orifice, through the anterior wall of the rectum. Continuous with this, and a little higher up, the posterior surface can also be made out through the second part of the bowel. The anterior surface receives the pubo-prostatic ligaments, and on this surface lies the greater part of the prostatic plexus. The lateral margins of the gland are embraced by the anterior borders of the levatores ani. The urethra, in its course through the organ from base to apex in the middle line, lies rather nearer to the anterior than the posterior surface. The ejaculatory ducts, as they pass obliquely through the prostate to open at the margins of the prostatic utricle, mark off a portion of the gland which lies between each duct below and the neck of the bladder above (fig. 959). This, though called the middle lobe, is not a distinct part of the prostate; it blends with the lateral lobes as an isthmus between them. It is obvious that, if this portion be enlarged, obstruction to the escape of urine from the bladder must follow. Up to puberty, the prostate is imperceptible per rectum. In adolescence the organ, while to be felt, is softer and more rounded, and lacks the character and shape which distinguish the organ in adult life. The capsule of the organ must be remembered. It is formed by a layer from the endo-pelvic (recto-vesical) fascia, and under it, especially on its anterior and

FIG. 959.—SAGITTAL SECTION OF MALE PELVIS IN THE MESIAL LINE. (One-third.) (Braune.)



lateral aspects, lies the prostatic plexus, formed by the breaking up of the dorsal vein of the penis.

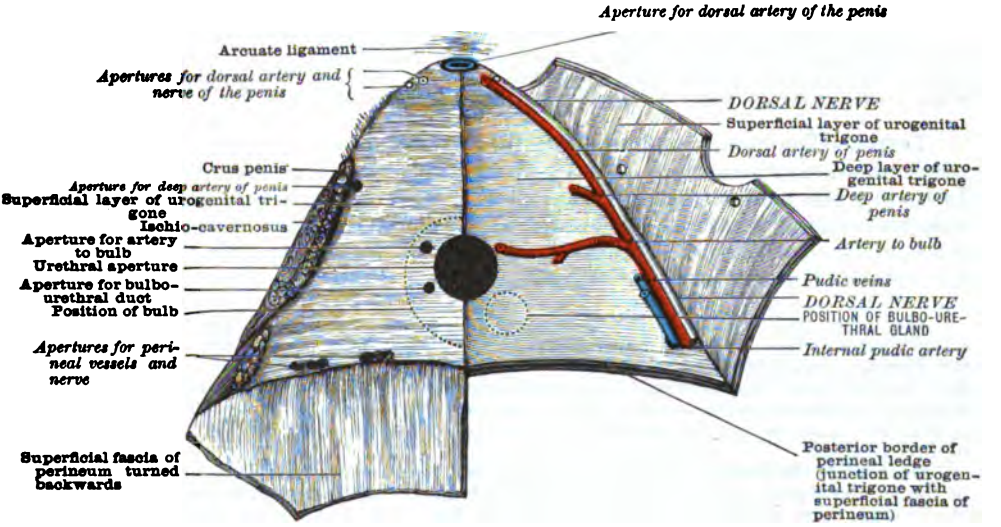
The continuity of the above sheath of the prostate with the endo-pelvic (recto-vesical) fascia on the upper surface of the levator ani and the sides of the bladder forms the roof of the perineum and part of the floor of the pelvis. If by mistake an incision, as in lateral lithotomy or supra-pubic prostatectomy, is carried through this prostatic sheath, the cavities of the pelvis will be opened and extravasation of fluids into the connective tissue, which everywhere follows the layers of pelvic fascia, will follow.

The **chief importance of the surgical anatomy of the prostate** is in its relation to lateral lithotomy (p. 1309), the so-called 'senile' enlargement, and prostatic abscess. Of the 'senile' enlargement there are two chief forms:—(*a*) The commonest. The glandular tissue plays the chief part, forming adenomata, and the prostate can be felt per rectum much enlarged and soft. The venous prostatic plexus is also much enlarged. (*b*) Here the fibro-muscular tissue is chiefly concerned, and examination of the prostate finds it hard. While the enlargement here is not pronounced, it may be quite sufficient to cause difficulty in micturition, especially if, as is usually the case, the muscular tissue of the bladder is failing. The presence of the prostatico-vesical plexus, usually much enlarged in later life, lying between the proper capsule of the prostate and that derived from the endo-pelvic fascia, with its thin-walled veins without valves, is a fertile source of hæmaturia, infective thrombosis, and hæmorrhage in removal of the organ. **Pros-**

tatic abscess is chiefly of importance from its tendency to burrow through the endo-pelvic fascia, or to open, as a fistula, in the rectum or on the perinæum. The best route to reach it is through the perineum. Before leaving the **relations of the prostate**, the reader should consider the **layers which will be met with in cutting down to this organ from the surface.** The following fasciæ and muscular layers will be met with successively (Cunningham):—(1) Skin and superficial fascia; (2) fascia of Colles; (3) superficial perineal muscles; (4) superficial layer of uro-genital trigone; (5) constrictor urethræ; (6) deep layer of uro-genital trigone; (7) levator ani; (8) capsule of prostate.

The bladder.—Relations of peritoneum.—The upper part of the bladder is covered by peritoneum reflected on it anteriorly from the abdominal wall and urachus, laterally from the sides of the pelvis along the obliterated hypogastric arteries, and, posteriorly, from the rectum or uterus. As the distending bladder opens out laterally and upwards, the corresponding peritoneal reflexions are carried with it, the anterior one being raised 2·5 to 5 cm. (1 to 2 in.) above the symphysis. But that forming the recto- or utero-vesical pouch does not alter its position to a corresponding degree. The position of the **urethral orifice** remains almost fixed, however much the upper, more mobile part of the bladder, varies in position. The level of this orifice usually lies about 2·5 cm. (1 in.) above that of a line passing through the lower margin of the symphysis and the end of the sacrum. *The interior of the bladder* shows the internal trigone with its boundaries. In front is the puckered orifice of the urethra, behind the two orifices of the ureters, about 4 cm. (1½ in.) apart.

FIG. 960.—SCHEME OF THE PUDIC ARTERY AND ITS BRANCHES.


Aperture for dorsal artery of the penis
Arcuate ligament
Apertures for dorsal artery and nerve of the penis
DORSAL NERVE
Superficial layer of urogenital trigone
Dorsal artery of penis
Crus penis
Deep layer of urogenital trigone
Aperture for deep artery of penis
Superficial layer of urogenital trigone
Deep artery of penis
Ischio-cavernosus
Aperture for artery to bulb
Artery to bulb
Urethral aperture
Pudic veins
Aperture for bulbo-urethral duct
DORSAL NERVE
Position of bulb
POSITION OF BULBO-URETHRAL GLAND
Apertures for perineal vessels and nerve
Internal pudic artery
Superficial fascia of perineum turned backwards
Posterior border of perineal ledge (junction of urogenital trigone with superficial fascia of perineum)

The exquisite sensitiveness of the neck and prostatic urethra, to which the vesical plexuses (sympathetic and third and fourth sacral) are largely distributed, the tendency of the trigone to sink as age advances, and, in the male, the so-called third lobe of the prostate to arise behind the urethral orifice, and the increasing development of the inter-ureteral bar, are to be remembered. The smoothness and fixity of the mucous membrane over the internal trigone contrast sharply with its laxity elsewhere. Fasciculation of the muscular coats may be temporary, as when due to the obstruction of a phimosis, or permanent, as in the causes of later life. Both are palpable to a sound.

Scrotum.—The coverings here are of two-fold origin. The *superficial*, e. g., dartos, on which the appearance of the part depends. The *deeper*, from the peritoneal sac and abdominal wall, brought down by the processus vaginalis in its descent (p. 1314).

The difficulty of adequately cleansing this delicate skin without overdoing the process is well known. While the laxity of the scrotum lends itself to distension, e.g., in ecchymoses, extravasation of urine, Bright's disease, its main blood-supply, the superficial perineal vessels, come from some way off, they are loosely supported, readily strangled; thus sloughing of the scrotum is, in spite of its vascularity, easily brought about.

Epididymis. Vas deferens. Testis.—The **epididymis,** the convoluted first part of the duct of the testis, about 6 m. (20 feet) in length, lies as a crescent around the posterior and outer part of the testis, its position here being important

in exploratory incisions, and in the characteristic feel of gonorrhœal and tubercular epididymitis. Its three portions are in differing connection with the testis. Thus the globus minor is held in place by connective tissue, the body by the same medium, and the inferior ligament (digital fold) of the tunica vaginalis propria; the globus major by the vasa efferentia. Thus, when tubercular disease begins here, the testis itself is more likely to be early involved.

Vas deferens.—The two extremities and the course of this involve several practical points. About 45 cm. (18 in.) long, it begins, convoluted at first and with a distinct bend upwards, in the globus minor. It thence passes almost vertically upwards at the back of the testis and cord to the spine of the pubes. Entering the canal, it lies on the grooved upper aspect of Poupart's ligament, and then under the arching fibres of the internal oblique and transversalis, upon the transversalis fascia. Its position, characteristic feel, and yellowish aspect are well-known guides in operations for varicocele and hernia, while it is always to be isolated and palpated when tubercular disease below is suspected. Leaving the canal by the internal ring, it hooks round the deep epigastric artery and then descends into the pelvis over the external iliac vessels. Continuing its course downwards and now backwards over the side of the pelvis, it arches backwards over the side of the bladder, superficial to the obliterated hypogastric artery, and then deep to the ureter. The two vasa now help to form the lateral boundaries of the external trigone, between the base of the bladder and the rectum. They here become dilated and sacculated and then contract again to empty into the ejaculatory ducts.

The sacculated conditions of the two extremities, with the pronounced bend at the commencement of the vasa, are fertile sources of catarrh here in inflammatory conditions, and explain why each of these spots is a nidus for micro-organisms. The sacculated ampulla is the part felt per rectum when enlarged, and is usually taken for the vesicula seminalis.

Testis.—The peculiar plumpness, firmness, and elasticity in health, with the normal testicular sensation, are to be recognised by repeated clinical examination. In tracing the **tunica vaginalis** the visceral layer covers all the inner surface, the anterior border, the outer surface as far as the epididymis, where it forms the sinus of the epididymis, the inner surface, anterior border, and outer surface of the epididymis, whence it is reflected as the parietal layer.

The upper prolongation of this serous sac along the cord and the persistent character of its epithelial surface are to be remembered in the radical cure of hydrocele. The strength of the **tunica albuginea** accounts for the severity of pain in inflammatory conditions, and the fact that for some time growths of the testis keep to the shape of the organ, with which goes their early extension to the lumbar nodes. The fact that there is no tunica albuginea around the epididymis accounts for the greater frequency of hydroceles secondary to diseased conditions of this structure

Descent of the testis.—During the greater part of intra-uterine life this organ is at the back of the lumbar region, just below the developing kidney. By the seventh month it has reached the internal ring; during the eighth it traverses the canal, and by the ninth should have descended into the scrotum. Preceding the descent, a diverticulum of peritoneum, the processus vaginalis, has made its way into the scrotum. Along this the testis, surrounded in front by the mesorchium, a peritoneal fold which ties the organ in place in its first home, descends. Normally the vaginal process should be closed, the process beginning above and below, shortly after birth; the parietal part of the tunica vaginalis being formed from this process, the visceral from the mesorchium. **Gubernaculum.**—This band-like structure, attached above to the testis, and below to the pubis, Poupart's ligament, and scrotum, consists of peritoneum and striped and unstriped muscle. It is best marked between the fifth and seventh months. How far its atrophy and traction on the testis play a part in the descent is uncertain. It is probable that the rapid growth of parts adjacent to the testis, and the pre-existence of the peritoneally lined tunnel are as important. A practical point is that the peritoneal portion of the gubernaculum (plica gubernatrix Lockwood) may be attached to other organs, e. g., cæcum, as well as the testis, thus accounting for the presence of these in congenital herniæ.

Spermatic cord.—This extends from the back of the testis to the abdominal inguinal ring, where its different constituents disperse. Like the scrotum, it has three chief coverings, gained from the abdominal wall. The **position of the vas** at the back of the cord, its characteristic thickened feel in tubercular and its tenderness in inflammatory conditions are always noteworthy. An enlargement of the cord generally may be helpful in suspected malignant disease; it is due partly to the enlargement of the spermatic vessels, partly to involvement of the lymphatics. The pampiniform plexus, normally eight to ten veins, extends from the testis to the external ring. In the canal it should be replaced by three or four veins accom-

panying the spermatic artery, which become the spermatic vein soon after their exit from the internal ring. The vein from the vas goes into the deep epigastric vein.

Where an operation has been decided to be really needful in varicocele, a very important point for decision is how far the alteration is merely an increase in the number of the veins, or an elongation rather than an increased number. In this case it is removal of a long segment which is required; where the number is increased, it is sufficient to remove the anterior group of the pampiniform plexus. Where the posterior group, that adjacent to the vas, is removed as well, a varying amount of fibroid atrophy of the testis is certain ultimately. The blood-supply, now depending upon the artery to the vas, is inadequate.

Penis.—A section through this organ in its posterior third would traverse the skin, loose, fatless cellular tissue, the dartos and dorsal vein, the fascia penis continuous behind with Colles's fascia (p. 1310), and receiving the fibro-elastic suspensory ligament. Under this fascia are the dorsal artery and nerve of each side and the corpora cavernosa, each in its tunica albuginea, which, fusing in the middle line, form the septum pectiniforme. The arteries to the corpora are close to this septum. In a groove below the corpora cavernosa lies the corpus spongiosum, in a more delicate sheath, with the urethra and artery to the bulb.

Ischio-rectal fossa.—Most of the boundaries of this space (p. 1212) can be made out with the finger in a thin subject. The loose, poorly vitalised fat which occupies it, the dependent position of the part, its terminal blood-supply, its exposure to cold and damp, and the close vicinity of decomposing fæces, all account for the frequency of abscess here, and its tendency to burrow and cause fistulæ unless opened early. The position of the pudic vessels and nerve in their sheath of obturator fascia, on the outer wall, about 4 cm. (1½ in.) above the lower margin of the tuber ischii, must be remembered.

Rectum and anal canal.—The rectum proper (second part of old description) begins at the third sacral vertebra, at the termination of the pelvic colon (p. 1305), and ends opposite the base of the prostate, where the bowel traverses the pelvic diaphragm to become the anal canal. It is always dilated from its function, in its lower part, habitual distension leading to a 'ballooned' condition. *Relations of peritoneum.*—An extension of the meso-colon of the pelvic colon covers at first the sides and front of the rectum, then the front only, being finally carried at the base of the recto-vesical pouch to the base and posterior surface of the bladder, or, in the female, to the upper part of the vagina. The level of this reflexion in both sexes may be stated to be, normally, about 7·5 cm. (3 in.) above the anus, but it is very liable to descend lower in patients with any tendency to procidentia of uterus, bladder, etc., and those with weak fasciæ and muscles. Under the peritoneum and in close contact with it the pelvic fascia forms a sheath to the rectum by its visceral layers, recto-vesical or recto-vaginal and rectal.

The curves of the rectum (wrongly called straight in the human subject) are important in the passage of bougies, etc. At first the bowel follows the curve of the cæcum and coccyx, then, at its junction with the anal canal, bending abruptly backwards and downwards to the anus. The surgical importance of many of the relations is to be remembered. The mobility of the upper part of the rectum and the pelvic colon allows of the bowel being readily dragged down in Kraske's operation, but care must be taken in division of the peritoneum not to divide the superior hæmorrhoidal artery, as the middle and inferior hæmorrhoidals will have been largely interfered with. Anteriorly, the close connection of the prostate and base of the bladder accounts for the facility with which infiltration takes place in malignant disease, the warning fixity of the bowel, and the formation of recto-vesical fistula. A calculus lodged in the vesical end of the ureter may perhaps be detected. Behind, the presence of the sacral nerves may explain, when early infiltrated by malignant disease, obscure pains along their distribution.

Here also the enlargement of the sacral nodes may be detected. Inside the bowel are the crescentic shelves known as the **transverse (Houston's) folds,** usually three in number—two on the left side, one on the right. This last, situated at about the junction of the rectum and the anal canal, may be large enough to interfere with the passage of tubes. Its unvarying appearance at the above spot suggests that it plays a part in the causation of carcinoma, in the irritation of neglected fæces.

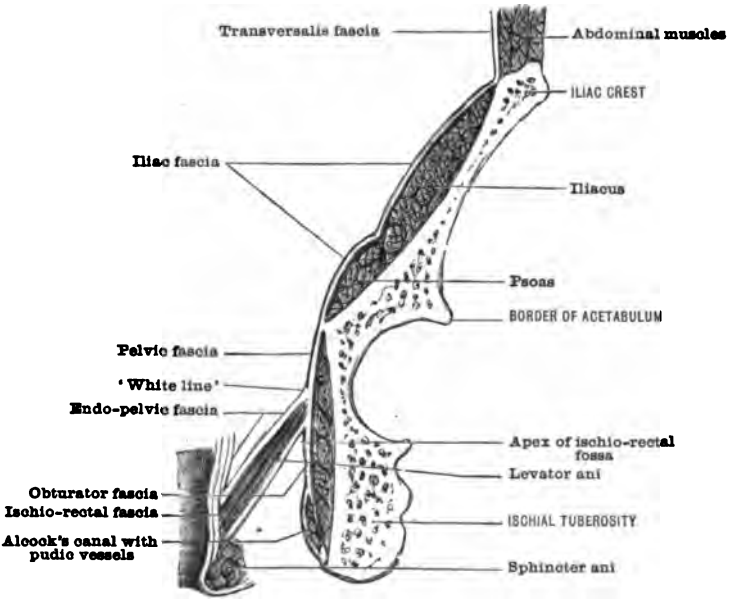
The anal canal.—This is the slit-like passage extending from the pelvic diaphragm downwards and backwards to the anus. About 3·7 cm. (1½ in.) long, it is surrounded by the sphincters and above by the levatores ani. On either side are

the ischio-rectal fossæ. Through this part of the bowel the finger, as it is gently insinuated, finds its first difficulty in a rectal examination.

Blood-supply to rectum.—The superior hæmorrhoidal artery, the continuation of the superior mesenteric, reaches the rectum proper in the back of the pelvic mesocolon; the two branches into which it quickly divides descend on either side of the bowel, and on the rectum proper break up into about six branches. At the junction of the rectum and anal canal these perforate the muscular coat and descend in the submucosa to anastomose with the other two rectal arteries. Of these, the inferior supplies the anal canal. The **venous hæmorrhoidal plexuses,** in the submucosa and on the outside of the bowel, communicate with the general and the portal systems. The **lymphatics** of the rectum enter the sacral and go to the lumbar nodes. Some along the middle hæmorrhoidal vessels gain the internal iliac group.

Anus.—The tightly closed condition of this orifice in health and the puckering of the skin around, due to the sphincter and corrugator cutis ani, are characteristic. Dilated veins, external piles, or tags of skin resulting from the shrinkage of these, are also common. A white line, varying in distinctness in different subjects, marks

FIG. 961.—DIAGRAM OF THE PELVIC FASCIÆ.



the junction of the skin and mucous membrane, and the interval between the external and internal sphincters. (Hilton.) At the upper part of the anal canal are the small permanent folds or columns of Morgagni, joined below by the crescentic anal valves.

In these small pockets hardened fæces may set up ulceration, or produce it by tearing down one of the valves (Ball), especially on the coccygeal aspect. The abundant nerve-supply (third and fourth sacral) to this region and the large distribution of the pudic nerve to the genitals, and the junction of this nerve with other branches of the sacral plexus explain the acuteness of the suffering, and its wide distribution in the affections of fissure and ulcer. (Hilton.)

The following points can be made out by the finger introduced into the rectum:—(1) The thickened, roll-like feel of a contracted external sphincter; (2) the narrower, more expanded, internal sphincter extending upwards for 2·5 cm. (1 in.) from this; (3) the rectal insertion of the levatores ani, which here narrows somewhat the lumen of the gut; (4) above the anal canal, with its contrasting capaciousness, is the more or less dilated rectum proper; (5) the condition of the ischio-rectal fossæ on either side; (6) the membranous urethra in front, especially if a staff has been introduced; the instrument now occupies the middle line, and has the normal amount of tissue between it and the finger, thus differing from one in a false passage (in a child an instrument is especially distinct); (7) just beyond the sphinc-

ters, or 3·7 cm. (1½ in.) within the anus, lies the prostate; (8) converging towards the base of the prostate, and forming the sides of the triangular space, are the vesiculæ seminales and ejaculatory ducts. These can rarely be felt unless diseased and enlarged; any enlargement of the sacculated ends of the vasa deferentia (p. 1180) is much more perceptible; (9) it is within this triangular space that the elasticity of a distended bladder can be felt. (10) Sometimes the lowest of the transverse folds (folds of Houston), on about the same level as the prostate, semilunar in form and about 1·2 cm. (½ in.) in width, can be made out (fig. 959). (11) Behind, the coccyx and its degree of pliability and the lower part of the sacrum. It may also be possible to feel enlarged sacral nodes and a growth from the other pelvic bones.

The above examination refers chiefly to the male. It remains to refer to **rectal examination in the female.** Anteriorly, the soft perinæal body and recto-vaginal septum will be met with, and, through the latter, the cervix and os uteri, and, higher up, the lower part of the cervix uteri. More laterally the ovaries may be felt, but the Fallopian tubes, unless enlarged and thickened, are not to be made out. The student should be familiar with the feel of a healthy recto-uterine or recto-vesical pouch, according to the sex, and the coils of intestine which it may contain, so as to be able to contrast this with any collection of inflammatory or other fluid or mischief descending from the upper pelvis, e. g., from the vermiform appendix. Posteriorly, certain structures are met with in either sex. After a very short interval (sphincter and ano-coccygeal body) the finger reaches the tip of the coccyx and explores the hollow of the sacrum. On each side are the ischial tuberosity and wall of the true pelvis. The finger, hooked outwards and upwards, comes on the border of the falciform process of the sacro-tuberous (great sacro-sciatic) ligament, passing between the above-mentioned bones.

The **pelvic fascia** and its chief layers are shown in fig. 961. These are described at p. 1228.

The following main points will readily be seen:—That the fascia has one important aspect towards the pelvic and another towards the ischio-rectal fossæ and perineum, and thus may be interfered with during operations, or affected by inflammation arising in either region. That its numerous processes and sheaths, while they serve to isolate different structures, are continuous, and that thus infective mischief may, as in the neck, spread most widely. With this fact go two other points: one, that with the planes of this fascia run layers of connective tissue; the other, that in the spaces tightly girt by this fascia lie large venous plexuses, e. g., vesical, hæmorrhoidal, prostatic, and, if infection reach these plexuses, it is out of reach of surgical treatment. The closeness of the fascia to the upper aspect of the hip-joint will also be remembered. In children with a thin acetabulum and hip disease this fascia becomes much thickened, thus shutting off the pelvic cavity from suppuration in the joint.

FEMALE GENITAL ORGANS

Under the external organs are included, for convenience sake, the labia majora and minora at the sides; and, in the middle line, from above downwards—(1) The glans clitoridis with its prepuce; (2) the vestibule; (3) the urethral orifice; (4) the vaginal orifice with the hymen or its remains; (5) the fossa navicularis; (6) the fourchette; (7) the skin over the base of the perineal body.

These parts have been described elsewhere, and only those points which are of importance in a clinical examination will be alluded to here.

The **labia majora** are two thick folds of skin, covered with hair on their outer surface, especially above, where they unite (*anterior commissure*) in the mons Veneris. They contain fat, vessels, and dartos, but become rapidly thinner below, where they are continuous with the fourchette in front of the perineum (their *posterior commissure*).

When the above folds are drawn aside, the **labia minora,** or **nymphæ,** appear, not projecting, in a healthy adult, beyond the labia majora. They are small folds of skin, which meet above in the prepuce of the clitoris, and below blend with the labia majora about their centre.

The glans clitoridis, covered by its prepuce, occupies the middle line above.

Below it comes the **vestibule,** a triangular smooth surface of mucous membrane, bounded above by the clitoris, below by the upper margin of the vaginal orifice, and laterally by the labia minora. In the middle line of the vestibule and towards its lower part, about 12 mm. (½ in.) below the glans clitoridis, and 25 mm. (1 in.) above the fourchette, is the meatus or opening of the urethra (figs. 873, 874).

The **vaginal orifice** lies in the middle line between the base of the vestibule above, and the fossa navicularis below. Its orifice is partially closed in the virgin by a fold of mucous membrane, the **hymen** (fig. 873). This is usually crescentic in shape, attached below to the posterior margin of the vaginal orifice, and with a free edge towards the base of the vestibule. In some cases it is diaphragmatic, i. e., attached all around, but perforated in the centre (fig. 873).

The shrivelled remains of the hymen probably constitute the **carunculæ myrtiformes.** On either side of the vaginal orifice, at its lower part, lie the racemose, muciparous, vestibular glands (glands of Bartholin), situated beneath the superficial perineal fascia and sphincter vaginæ. Their ducts run slightly upwards and open, external to the attachment of the hymen, within the labia minora. In relation to the upper two-thirds of the vaginal orifice, placed between the uro-genital trigone behind and the sphincter vaginæ in front, are the vascular bulbs of the vagina, rupture of which produces pudendal hæmatocele.

Fourchette and fossa navicularis.—The fourchette, as stated above, is the lower commissure of the labia majora. Normally the inner aspect of this is in contact with the lower surface of the hymen. When the fourchette is pulled down by the finger, a shallow depression is seen, the **fossa navicularis,** with the fourchette for its posterior, and the hymen for its anterior, boundary.

Examination per vaginam.—The finger, introduced past the gluteal cleft, perineum, and fourchette, comes upon the elliptical orifice of the vagina, and notes how far it is patulous or narrow; the presence or otherwise of any spasm from the adjacent muscles; then, passing into the canal itself, the presence or absence of rugæ, a naturally moist or a dry condition are observed. In the anterior wall the cord-like urethra can be rolled between the finger and the symphysis; and further up than this, if a sound be passed, the posterior wall of the bladder. The anterior wall of the vagina is about 6·7 cm. (2½ in.) long. The posterior wall, 7·5 cm. (3 in.) long, forms the recto-vaginal septum, and through it any fæces present in the bowel are easily felt. The cervix uteri is next felt for in the roof of the vagina, projecting downwards and backwards in a line drawn from the umbilicus to the coccyx. Besides its direction, its size, shape, mobility, and consistence should be noted. The os uteri should form a dimple or fissure in the centre of the cervix. Of its two lips, the posterior is the thicker and more fleshy feeling of the two. The vaginal *culs-de-sac* or fornices are next explored. These should be soft and elastic, giving an impression to the finger similar to that when it is introduced into the angles of the mouth. Any resistance felt here may be due to scars, swellings connected with the uterus (displacements or myomata), effusions of blood or inflammatory material, and, in the case of the lateral *culs-de-sac*, a displaced or enlarged ovary, or dilatations of the Fallopian tubes. The posterior cul-de-sac is much deeper than the anterior, and, owing to the peritoneum descending upon the posterior wall of the vagina, when the finger is placed here it is only separated from the peritoneal sac by the vaginal wall and pelvic fascia. In examination of the pelvic organs the bimanual method, by which one hand, on the hypogastric region, pushes them down and steadies them as well, is always to be employed to complete an examination.

The ovary.—This lies in a fossa at the back of the side wall of the pelvis, just below the external iliac vessels. To feel it, the finger should be pushed well up in the side of the vagina towards the above-mentioned wall of the pelvis. On the surface its position corresponds to the middle of a line drawn from the anterior-superior spine of that side to the opposite pubic spine. (Rawlings.)

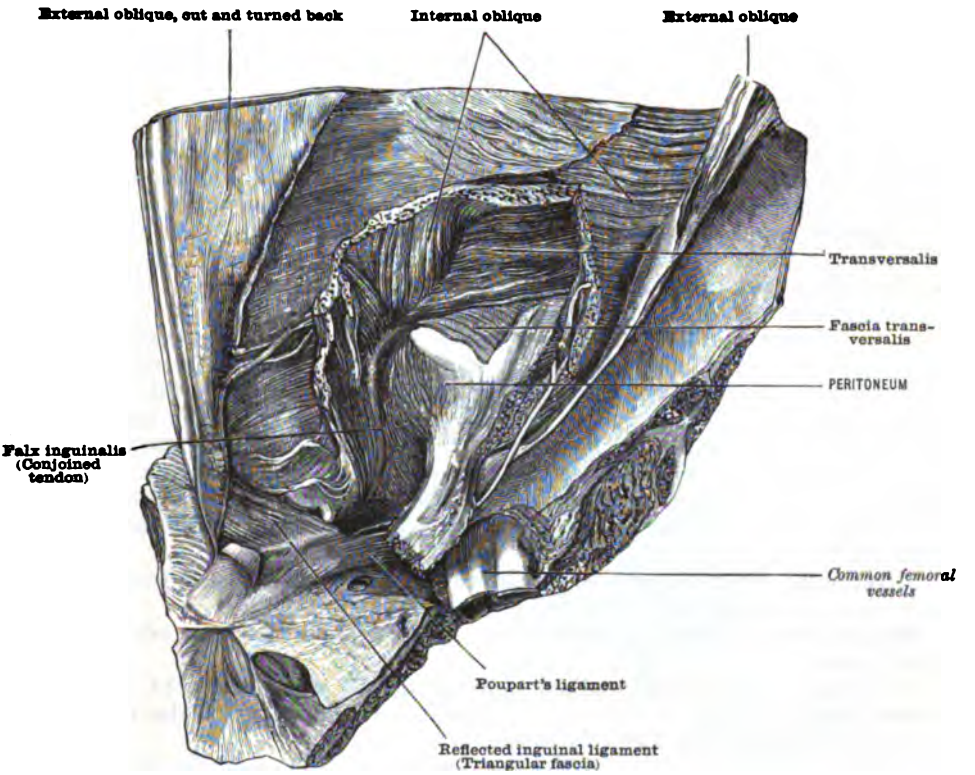
The ureter.—The pelvic portion of this is of especial importance in operations on the uterus and upper vagina. The duct crosses the brim of the pelvis over the common iliacs close to their bifurcation. The corresponding point on the surface is at the junction of the outer and middle thirds of a line joining the anterior-superior spines. (Stiles.) It then curves downwards and forwards, to enter the bladder, running close to the side of the cervix uteri, where it is crossed by the uterine artery, passing inwards and to the upper part of the vagina. Sometimes a calculus lodged in the lowest part of the ureter may be detected in the side of the vaginal fornix by pressing the foreign body against the pelvic wall.

HERNIA

PARTS CONCERNED IN INGUINAL HERNIA

In inguinal hernia, as in femoral and umbilical, there is a weak spot in the abdominal wall—one weakened for the needful passage of the testicle from within to outside the abdomen (p. 1314). The parts immediately concerned are the two inguinal (abdominal) rings, subcutaneous (external) and abdominal (internal), and the canal. Now, it must be remembered at the outset that the rings and canal are only potential—they do not exist as rings or canal save when opened up by a hernia, or when so made by the scalpel. The canal is merely an oblique slit or flat-sided passage. The external and internal rings are so intimately blended with the structures that pass through them, and so filled by them, that they are potential rings only.

FIG. 962.—THE PARTS CONCERNED IN INGUINAL HERNIA.
(From a dissection in the Hunterian Museum.)



The subcutaneous inguinal (external abdominal) ring.—This is usually described as a ring: it is really only a separation or gap in the aponeurosis of the external oblique, by which in the male the testicle and cord, and in the female the round ligament by which the uterus is kept tilted a little forwards, pass out from the abdomen. The size of this opening, the development and strength of its sides or pillars, the fascia closing the ring—all vary extremely. **Formation:** by divergence of two fasciculi of the external oblique aponeurosis. **Boundaries:** two crura—(1) Superior (internal pillar), the smaller, attached to the symphysis and blending with the suspensory ligament of the penis; (2) inferior (external pillar), stronger, attached to the pubic spine and blending with Poupart's ligament, and so with the fascia lata. On this inferior, stronger crus rests the cord (and so the weight of the testicle) or round ligament. **Shape:** triangular or elliptical, with the base downwards and inwards towards the pubic crest.

Intercrural fibres (intercolumnar fascia).—Tunica vaginalis communis (external spermatic fascia).—This, derived from the lower part of the aponeurosis of the external oblique, ties the two crura together, and, being continued over the cord, prevents there being any ring here, unless made with a scalpel. This is the rule in the body: when any structure passes through an opening in a fibrous or muscular layer, it carries with it a coating of tissue from that layer; e. g., the inferior cava passing through its foramen in the diaphragm, and the membranous urethra through the uro-genital trigone.

Effect of position of the thigh on the ring.—As the lower crus is blended with Poupart's ligament, and as the fascia lata is connected with this, movements of the thigh will affect the ring much, making it tighter or looser. Thus extension and abduction of the thigh stretch the crura and close the ring. In flexion and adduction of the thigh the crura are relaxed; and this is the position in which reduction of a hernia is attempted. In flexion and abduction of the thigh, the ring is open; and this is the position in which a patient should sit, with thighs widely apart, to try on a truss, and cough or strain downwards, as in rowing. If the hernia is now kept up, the truss is satisfactory.

Helping to protect this most important spot, and preventing its being more than a potential ring, are not only the two pillars and the intercrural fibres, but also a structure which has been called a third or posterior pillar, namely, the **reflected inguinal ligament (triangular fascia).** This has its base above at the lower part of the linea alba, where it joins its fellow and the aponeurosis of the external oblique, and its apex downwards and outwards, where, having passed behind the internal pillar, it blends with the lacunar (Gimbernat's) ligament. Again, the **falx inguinalis** (the conjoined tendon of the internal oblique and transversalis), curving inwards and downwards to be attached to the ilio-pectineal line and spine, is a most powerful protection, behind, to what is otherwise a weak spot and a potential ring.

Inguinal canal.—This is not a canal in the usual sense, but a chink or flat-sided passage in the thickness of the abdominal wall. The descriptions of the canal usually given apply rather to the diseased than to the healthy state. It was a canal once, and for a time only, i. e., in the later months of fœtal life (p. 1314). It remains weak for a long time after, but only a vestige of it remains in the well-made adult.

Length.—In very early life there is no canal; one ring lies directly behind the other, so as to facilitate the easy passage of the testis. In the adult it measures about 37 mm. (1½ in.) in length, this lengthening being brought about by the growth and separation of the alæ of the pelvis. This increased obliquity gives additional safety. On the other hand, a large hernia has not only opened widely the canal and rings, but it has pulled them close together, and one behind the other, thus not only rendering repair much more difficult, but also the path to the peritoneal sac shorter and more direct.

Direction.—From the abdominal (internal) to the subcutaneous (external) ring, downwards, forwards, and inwards.

Boundaries.—For convenience sake, certain limits (largely artificial) have been named:—

(1) *Floor.*—This is best marked near the outlet, where the cord rests on the grooved upper margin of Poupart's ligament. The meeting of the transversalis fascia with this ligament forms the floor.

(2) *Roof.*—The apposition of the muscles and the arched border of the internal oblique and transversalis.

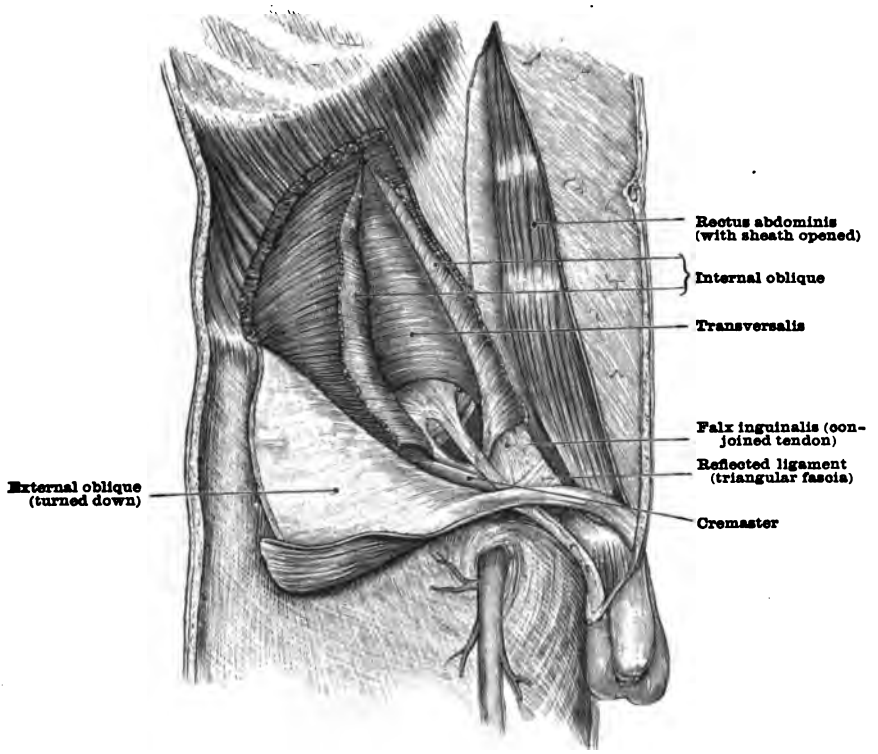
(3) *Anterior wall.*—Skin, superficial fascia, external oblique for all the way. Internal oblique, i. e., that part arising from Poupart's ligament, for the outer third or so.

(4) *Posterior wall.*—For the whole extent, transversalis fascia, extra-peritoneal tissue, and peritoneum. For the inner two-thirds, conjoined tendon of internal oblique and transversalis, and the outer edge of the reflected inguinal ligament (triangular fascia), when developed. The transversalis fascia is thicker and better marked at its attachments below; these are—(*a*) externally, to inner lip of iliac crest; (*b*) to Poupart's ligament between the anterior-superior spine and the femoral vessels, where it joins the fascia iliaca; (*c*) opposite the femoral vessels it also joins the fascia iliaca, and forms with it a funnel-shaped sheath; (*d*) internal to the femoral vessels the fascia transversalis is attached to the terminal (ilio-pectineal) line, behind the conjoined tendon, with which it blends. The *falx inguinalis* (*con-*

joined tendon) needs special reference. It is formed by the lower fibres of the internal oblique and transversalis (arciform fibres) arching downwards over the cord to be inserted into the crest and spine and the terminal (ilio-pectineal) line. The fibres of the internal oblique become increasingly tendinous as they descend, and this, with the fact that below they give off the cremaster, may cause some difficulty in their identification when it is desired to unite them to the upper surface of Poupart's ligament in the operation of radical cure.

The abdominal inguinal (internal abdominal) ring.—It has already been said that the term 'ring' is here misapplied except in an artificial sense, as when an opening is made by a scalpel; or in a pathological one, as when a hernia is making its way by opening up the parts. The terms 'internal' and 'external' are also misapplied as far as their usual application to the middle line of the body is concerned. The terms apply to depth only. The 'internal' ring is not a ring in the least, but merely a funnel-shaped expansion of the transversalis fascia, which the cord carries on with

FIG. 963.—DISSECTION OF INGUINAL CANAL. (Wood.)



it as it escapes from the abdomen. This expansion may be weakened, but it is never an opening save when made so artificially.

Site.—Midway between the anterior-superior spine and pubic tubercle (spine). **Shape:** oval, with the long diameter upwards. **Dimensions:** 25 mm. (1 in.) by 12 mm. (½ in.). Both these are artificial. **Boundaries:** centre of Poupart's ligament, about 12 mm (½ in.) below. Internally, the inferior epigastric artery (fig. 964); the position of this vessel, by its pulsation, is an important guide to the insertion of the highest sutures between the arciform fibres and Poupart's ligament. Owing to the artery lying to the inner side, the incision, in cutting to relieve the deep constriction of an inguinal hernia, should always be made directly upwards, so as to avoid the above vessel. A large oblique hernia may so have altered the relations of the parts, including the artery, that it is difficult to decide whether the hernia is oblique or direct. The above incision will be safe, because, in either case, parallel to the vessel.

Coverings.—There are two chief forms of inguinal hernia:—

A. The common form: external, or oblique.—External, because it appears

(at the abdominal (internal) ring) external to the inferior epigastric artery. **Oblique,** because it traverses the whole of the inguinal canal, entering it at its inlet and leaving it at its outlet.

B. **Rarer form: internal, or direct.**—**Internal,** because it appears internal to the inferior epigastric artery. **Direct,** because, instead of making its way down the whole oblique canal, it comes by a short cut, as it were, only into the lower part of the canal, and then emerges by the same opening as the other.

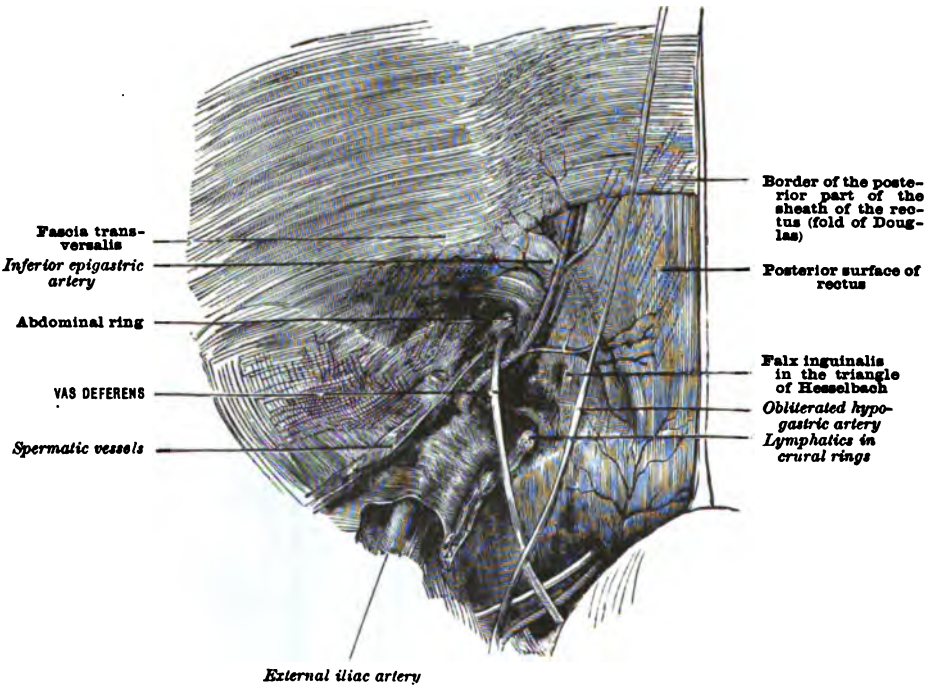
A. **Oblique external inguinal hernia.**—This possesses its **coverings** as follows:—

(1) **At the abdominal (internal) ring,** or **inlet,** it obtains three:—(*a*) Peritoneum; (*b*) extra-peritoneal fat; (*c*) infundibuliform fascia, or the vaginal process of transversalis fascia prolonged at this spot along the cord.

(2) **In the canal** it obtains one. As it emerges beneath the lower border of the internal oblique it gets some fibres from the cremaster.

(3) **At the subcutaneous (external) ring,** or **outlet,** the hernia obtains three, viz.: (*a*) Intercrural fibres (intercolumnar fascia); (*b*) superficial fascia; and (*c*) skin.

FIG. 964.—DISSECTION OF THE LOWER PART OF THE ABDOMINAL WALL FROM WITHIN, THE PERITONEUM HAVING BEEN REMOVED. (Wood.)


Fascia transversalis
Inferior epigastric artery
Abdominal ring
VAS DEFERENS
Spermatic vessels
Border of the posterior part of the sheath of the rectus (fold of Douglas)
Posterior surface of rectus
Falx inguinalis in the triangle of Hesselbach
Obliterated hypogastric artery
Lymphatics in crural rings
External iliac artery

B. **Direct or internal inguinal hernia.**—This does not come through the internal ring, but, making its way through the posterior wall of the lower third of the canal, either through the internal or middle inguinal fossa. Its coverings, therefore, vary slightly with its mode of exit (*vide infra*).

Hitherto the two forms of inguinal hernia have been considered from the **superficial aspect,** that in which they are met with in practice. The inguinal region should also be studied as to the **posterior aspect** of its so-called rings and canal, as these have to bear the early stress of a commencing hernia. It is against this aspect that a piece of omentum or intestine is constantly and insidiously pressing and endeavouring to make its way out. Furthermore, when either of the above constituents of hernia have made their way a little farther, and got out into the internal ring or into the canal, the patient is no longer sound.

On the posterior wall are certain cords and depressions, marking off regions which correspond to those on the surface.

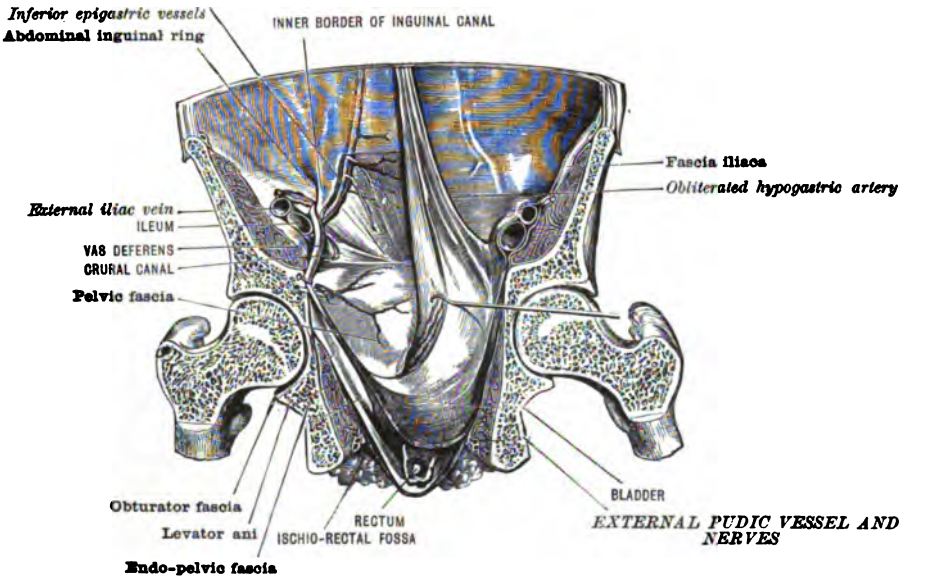
Thus, there are three prominent **cords** and three **fossæ** (figs. 964 and 965).

Three cords—(1) Median, or **urachus**; (2) lateral, or the **obliterated hypogastric arteries.**

(1) Median, or urachus. This interesting fœtal relic, the intra-abdominal part of the allantois, passes up between the apex of the bladder and the umbilicus, and by so doing—(*a*) keeps the bladder up, especially in early life, when the pelvic cavity is but little developed; (*b*) it keeps the bladder well up so that it shall be above the level of the urethra, and so more easily emptied; (*c*) it provides, by thus keeping up the bladder, that it shall enlarge in a direction which will admit of the greatest amount of distension, i. e., one between the lower or yielding part of the abdominal wall and the hollow of the rectum, which is compressible.

(2) The obliterated hypogastric arteries. These, the remains of vessels which during fœtal life carry the impure blood of the fœtus out to the mother through the umbilicus, run up and join the urachus at the umbilicus. In relation to these cords are the following **fossæ**:—(*a*) An **internal** one, between the urachus and the obliterated hypogastric artery. This corresponds, on the anterior surface, to the subcutaneous inguinal (external abdominal) ring. Through this fossa comes the commonest form of direct inguinal hernia. (*b*) Between the obliterated hypogastric artery and the inferior epigastric artery, running upwards and inwards to

FIG. 965.—POSTERIOR PART OF LOWER WALL OF ABDOMEN WITH THE DIFFERENT STRUCTURES ON IT. (Blandin.)



form the outer boundary of Hesselbach's triangle, is a **middle fossa.** This is the smallest of all. The rarer form of direct hernia comes through here. (*c*) The **external fossa** is outside the inferior epigastric artery. It is the most distinct of the three, from the way in which the cord or round ligament passes down within a glove-like vaginal process of the transversalis fascia. This fossa corresponds to the internal ring.

The coverings of an internal or direct hernia may now be considered, together with **the two-fold manner of exit** of this hernia. It only traverses the lower part of the canal, making its way through either the internal or the middle inguinal pouch. (i) The commonest form, coming through the internal inguinal pouch, either pushes its way through or stretches before it the falx inguinalis. Its coverings are:—(1) Peritoneum; (2) extra-peritoneal fat; (3) transversalis fascia; (4) falx inguinalis (unless this is suddenly burst through) (5) (6) (7). At the external ring the three coverings are the same as in the oblique variety. (ii) This rarer form of direct hernia comes through the middle inguinal pouch. As a rule, the falx inguinalis does not reach over this fossa. The coverings will be the same as in the last, with two exceptions—there is no falx inguinalis, and the cremasteric fascia, if well developed, will be present.

Varieties of inguinal hernia according to the condition of the vaginal process of peritoneum.—Inguinal herniæ have above been classified according to their relation to the deep epigastric artery. It remains to allude to the arrangement of these same herniæ according to the varying condition of the **processus vaginalis.** This pouch of peritoneum, which paves the way for the passage of the testis before this organ makes its start, eventually becomes the parietal layer (p. 1176) of the tunica vaginalis below, in this fashion: During the first few weeks after birth the process becomes obliterated at two spots—one near the internal ring, and one just above the testis. The obliterative process, commencing first above and descending, and then, ascending from below, the shrivelling continues until nothing is left save the tunica vaginalis below. The following are possible hernial results of an imperfect obliteration of the process—the first, alone, is common:—

(1) If the process does not close at all, a descending **hernia** is called **congenital.** This may make its way into the scrotum. The testis is now enveloped and concealed by the hernia.

(2) If the process is closed only above, i. e., near the internal ring, two varieties may be met with, *the infantile* and the *infantile encysted*. In the *infantile*, owing to pressure above, the weak septum gradually yields and forms a sac behind the unobliterated lower part of the processus funiculo-vaginalis. Thus three layers of peritoneum may now be met with in an operation, the two of the incompletely obliterated tunica vaginalis, and the proper sac of the hernia. In the **encysted infantile** variety the hernial pressure causes the septum to yield and form a sac projecting into, not behind, the incompletely obliterated tunica vaginalis. Here, theoretically, two layers of peritoneum will be met with. Another variety of such an encysted hernia may be produced by rupture, not stretching, of the above-mentioned septum.

(3) If the processus vaginalis be closed below and not above, a patent tubular process of peritoneum will lead down as far as the top of the testis. Any hernia into this process is called a **hernia into the funicular process.** All these varieties save the congenital and hernia into the funicular process are rare in practice. Other practical points are that all herniæ in children and young adults are probably of congenital origin, and, therefore, the weakness is bilateral, though it may not be so palpably. This applies to both sexes. Again in hernia of sudden origin into the funicular process with narrow surroundings, strangulation may be very acute.

Inguinal hernia in the female.—The inguinal canal in women is smaller and narrower than in men. Inguinal hernia is, therefore, uncommon in the female sex, and only occurs before adolescence, in patients who happen to be the subjects of an unobliterated processus vaginalis, which extends for a varying distance along the round ligament, and is called the canal of Nuck. Inguinal hernia in the female is, therefore, always congenital. It is, practically, always of the oblique variety, and travels along the round ligament towards the labium majus. Its coverings will be the same as those of the oblique variety in the male, save that the cremaster, as a distinct muscle, is absent, and any fibres of the internal oblique which may be present are but little developed.

Causes of hernia.—It will be well, while the anatomy of hernia is being considered, to refer briefly to the causes, as many of these are intimately bound up with the anatomy of the parts. Amongst the chief are the following:—

(1) **Hereditary,** viz., weakness of abdominal wall; openness of rings.

(2) **Weak spots.**—(*a*) The presence of the cord; (*b*) deficiency of some of the layers below; (*c*) persistence of the original process of peritoneum; (*d*) a long or relaxed mesentery, or a weakened suspensory ligament of the intestines (ligament of Treitz, p. 1104). In these days when operations for 'radical cure' are so frequent, it will be well here to summarise the chief points in the surgical anatomy which need consideration before such operations are undertaken. In inspection of the patient both erect and lying down, there should be no bulging or overhanging of the hypogastric region, such a condition being due not only to subcutaneous fat, but to the far more serious relaxation, weakening, and lengthening of the mesentery and its root, and then an undue excursus of the intestines; and to a loaded and elongated omentum. Laterally, the inguinal region should show no funnel-like bulgings. The rings and canal should be but little dilated, the muscles firm, such as will show a healthy red section. The younger the patient, after early childhood, the better the prognosis, as the parts are developing and the muscles can still gain strength. In Mr. Lockwood's words, the defect is here a local one, consisting chiefly in an open vaginal process. In **acquired hernia** the defect is more wide-spread, all the tissues tending to be more or less degenerated. Mr. Lockwood has shown that the mesentery is relatively longer in infancy, and that there is a rapid decrease after the second year. In adults its length is about 20 cm. (8 in.), and any lengthening of the mesentery beyond this point is likely to be combined with a protuberant belly. He shows further, with regard to the range of descent

or the excursus of the intestines, that after adolescence it is extremely rare to find a mesentery so short, or attached so high as to prevent the intestines escaping or being drawn from the abdomen.

(3) Stretching of the abdominal walls by pregnancies, etc.

(4) Increase of the volume and weight of the parts within: e. g., omentum by deposit of fat in it.

(5) Sex. Thus, men have larger inguinal rings. Women have a larger femoral arch, and one less well filled in by muscles, and with less strong fasciæ meeting, e. g., iliac and transversalis.

(6) Cough, asthma, bronchitis, habitual fretfulness or crying.

(7) Straining to expel urine, as with phimosis, stricture, stone in bladder, etc.

(8) Straining in defecation.

(9) Lifting heavy weights.

(10) Results of wounds or abscesses which have weakened the abdominal wall.

(11) Whatever diminishes the abdominal cavity, e. g., tight lacing.

FEMORAL HERNIA

As many of the parts concerned here are also met with in inguinal hernia, one description, given now, will suffice.

With regard to descriptions of the inguinal and femoral regions, it is always well to bear in mind the following:—(1) That the so-called rings and canals are merely weak spots in the inguinal and femoral regions, and that they do not exist distinctly, and do not get beyond the potential stage, unless made by a scalpel or a hernia; (2) that at the fold of the groin most of the layers blend together, and that descriptions of them as separate layers, for convenience sake in learning them, are more or less artificial; (3) that the description of these layers has been most needlessly complicated by the number of terms used, many of which are simply substitutes for others; (4) many of these terms are not only useless but incorrect, e. g., saphenous, crural, etc.

Parts concerned in femoral hernia.—(1) **Skin and superficial fascia of groin.**—The latter consists of two layers: (*a*) **Superficial layer of superficial fascia.**—Fatty, met with over the whole groin, and continuous with the superficial fascia of the rest of the body. (*b*) **Deep layer of superficial fascia.**—Thin and membranous, only met with over the lower third of the abdominal wall and to the inner side of the groin. It is continuous through the scrotum with the deep layer of the superficial fascia of the perineum. Just below Poupart's ligament it is joined to the fascia lata. From these two facts it results that in rupture or giving way of the urethra the extravasated urine may come forwards by way of the genitals (p. 1310) and from the continuity of the fascia make its way on to the abdomen, but not down on to the thigh.

Between the two layers of superficial fascia lie the superficial nodes of the groin, the superficial branches of the common femoral artery, one or two cutaneous nerves, and some veins descending to the fossa ovalis to join the great saphenous vein.

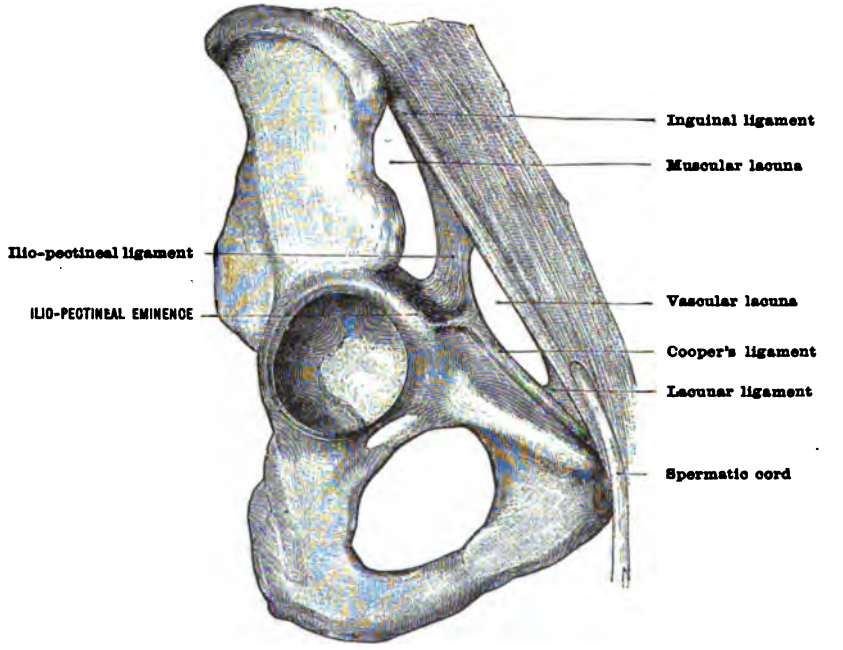
(2) **Inguinal (Poupart's) ligament.**—This is also known as the crural arch, a misnomer, as 'crus' means leg. A description of its shape and attachments is given on p. 1299. Owing to the connection of the fascia lata to its lower border, the fossa ovalis (saphenous opening), which is situated in the fascia lata, and has its upper cornu blending with Poupart's ligament, will be affected by movements of the thigh, much as is the subcutaneous inguinal (external abdominal) ring, being tightened and stretched when the limb is extended and abducted, relaxed when it is adducted and flexed.

The **parts beneath the ligament** which block up the gap between it and the innominate bone are of the utmost importance in preventing the escape of a femoral hernia (fig. 996).

The different structures are arranged in three compartments (fig. 966), named from without inwards:—A. **Outer, iliac,** or **muscular**; B. **Central,** or **vascular**; and C. **Inner,** or **pectineal.** Of these, the first is the largest; the second or central one lies slightly nearer to Poupart's ligament than the other two; while the innermost compartment differs from the other two by not communicating with the pelvis, being closed above (*vide infra*). (A) The **outer,** or **iliac, compartment** is bounded in front by Poupart's ligament and the iliac fascia, which is here blending with it, behind by the ilium, externally by this bone and the sartorius, and internally by the ilio-pectineal septum, which, descending from the blending of the iliac fascia and Poupart's ligament above, passes down to the ilio-pectineal eminence, and thence to the inner aspect of the front of the capsule of the hip-joint. This compartment

transmits the ilio-psoas and femoral (anterior crural) and external cutaneous nerves. (B) The **central, or vascular, compartment** is bounded, in front, by Poupart's ligament and the transversalis fascia, which here blends with it, forming the so-called deep crural arch, and at the same time descends on to the front of the femoral sheath. The posterior boundary is formed by the meeting of the ilio-pectineal septum externally and the pectineal fascia or sheath from within—internally the lacunar (Gimbernat's) ligament, and externally the ilio-pectineal septum. This central compartment transmits the external iliac vessels and the lumbo-inguinal nerve. This lies to the outer side of the artery, the vein internally. Between the vein and the base of the lacunar (Gimbernat's) ligament is the femoral canal (*vide infra*). (C) The **innermost, or pectineal, compartment** is bounded by the pectineal fascia, continuous with the pubic part of the fascia lata, and behind by the pubic ramus. It lodges the upper end of the pectineus muscle, and the handle of a scalpel passed upwards along the muscle would be prevented from passing into the pelvis by the lacunar (Gimbernat's) ligament and the blending of the pectineal fascia with the upper border of the pubic ramus.

FIG. 966.—THE LACUNÆ BENEATH THE INGUINAL LIGAMENT. (Lockwood.)



(3) **Lacunar (Gimbernat's) ligament.**—This is merely the triangular internal attachment of Poupart's ligament. Its apex is attached to the pubic spine; of its three borders, the base is free towards the vein and the femoral canal. Its upper border is continuous with Poupart's ligament; its lower is attached to the ilio-pectineal line.

(4) **Fascia lata.**—Two portions are described over the upper part of the thigh:—(*a*) An **iliac,** external and stronger, attached to Poupart's ligament in its whole extent and lying over the sartorius, ilio-psoas, and rectus. (*b*) A **pubic,** internal, weaker, and much less well defined, is attached above to the terminal (ilio-pectineal) line and the spine of the pubes. The upper cornu of the fossa ovalis (saphenous opening) is at the lacunar (Gimbernat's) ligament, and at the lower cornu the two portions of the fascia blend.

Their relation to the femoral vessels.—The iliac portion, being attached along Poupart's ligament, passes over these. The pubic portion, fastened down over the pectineus, which slopes down on to a deeper plane than the adjacent muscles, passes behind the femoral vessels to end on the capsule of the hip-joint.

(5) **Fossa ovalis (saphenous opening).**—This is not an opening, but an oval

depression, situated at the spot where the two parts of the fascia lata diverge on different levels. Though the fascia lata is wanting here, there is no real opening, as the deficiency is made up by the deep layer of superficial fascia, or cribriform fascia, which fills up the opening.

Uses of the fossa ovalis (saphenous opening).—Though a weak spot, it is so on purpose to transmit the saphenous to the femoral vein, and the superficial to the deep lymphatics. It is by these lymphatics that the lumbar nodes become insidiously affected, usually by the time that a patient with epithelioma of the penis comes for treatment. The depression is present in order to allow the saphenous vein to be protected from pressure in flexion of the thigh.

Site.—At the inner and upper part of the thigh, with its centre 3·7 cm. (1½ in.) below and outside the tubercle (spine) of the pubis.

Diameters.—Vertically, 2·5 cm. (1 in.), by 1·2 or 1·8 cm. (½ or ¾ in.). *Shape:* oval, with its long axis downwards and outwards. *Two extremities* or *cornua:* upper blending with the lacunar (Gimbernat's) ligament; lower, where the two parts of the fascia lata meet. *Two borders:* outer or falciform, also known as the ligament of Hey, or femoral ligament. Semilunar in shape, arching downwards and outwards from the lacunar (Gimbernat's) ligament to the inferior cornu. This lies over the femoral vessels, and is adherent to them; to it is fixed superficially the cribriform fascia (*vide infra*). The inner border is much less prominent, owing to the weakness of the pubic part of the fascia lata which forms it.

(6) **Femoral sheath.**—This is a funnel-shaped sheath, carried out by the femoral vessels under Poupart's ligament, and continuous above (in front) with the transversalis fascia as it descends to the ligament, lining the inner surface of the abdominal wall, and (behind) with the iliac fascia, and below continuous with the proper sheath of the femoral vessels.

It is not only funnel-shaped, but large and loose, for two reasons:—(*a*) That there be plenty of room for the femoral vein and the slowly moving venous current in it to ascend without compression; (*b*) to allow all the movements of the thigh taking place—flexion and extension—without undue stretching of the vessels. By two connective-tissue septa the sheath is divided into three compartments—the outer for the artery, the middle for the vein, and the internal one for the femoral canal (*vide infra*). Thus one septum lies between the artery and vein, and another between the vein and the femoral canal.

(7) **Femoral canal.**—Definition: the innermost division of the femoral sheath. The fascia transversalis and fascia iliaca meet directly on the outer side of the femoral artery, but not so closely on the inner side of the femoral vein. Hence a space exists here, perhaps to prevent the thin-walled vein, with its sluggish current, being pressed upon, but it is merely a slight gap—not a canal, unless so made by a knife or by the dilating influence of a hernia. *Length:* about 1·9 cm. (¾ in.). *Limits:* below, fossa ovalis (saphenous opening); above, femoral ring (*vide infra*).

Boundaries.—Externally, a septum between it and the vein; internally, base of the lacunar (Gimbernat's) ligament and meeting of fascia iliaca and transversalis; behind, fascia iliaca; in front, fascia transversalis.

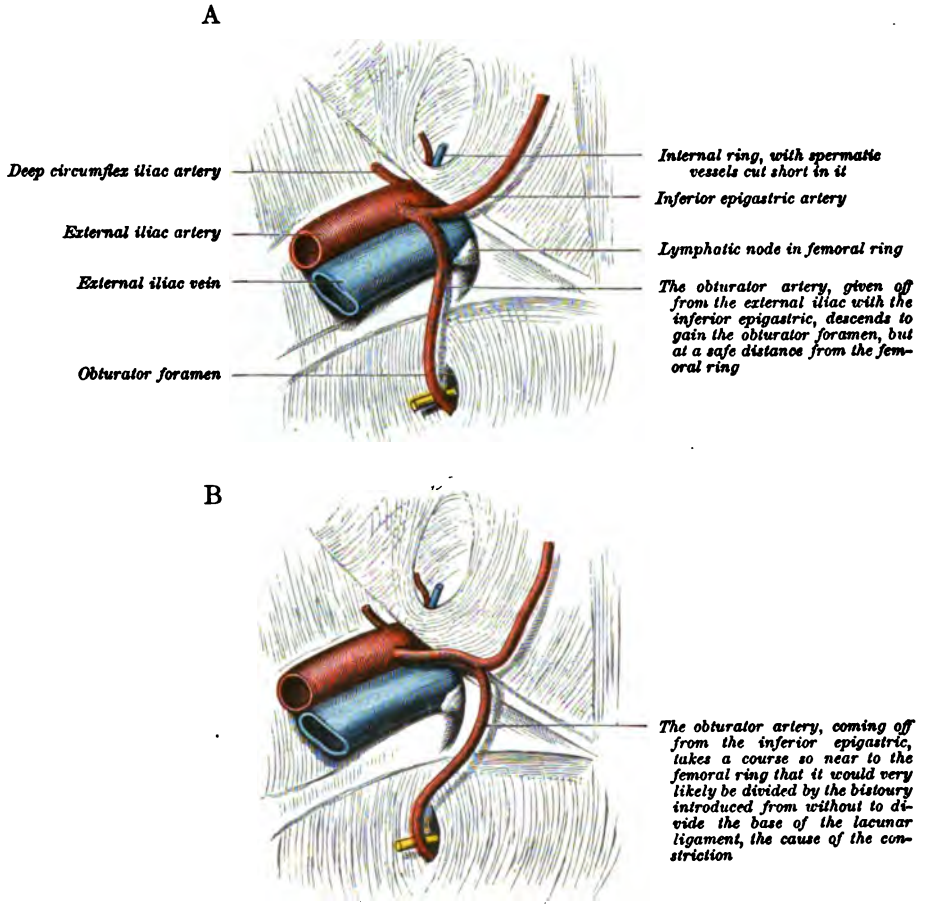
Contents.—Cellular tissue and fat, continuous with extra-peritoneal fatty layer. A lymphatic node, which is inconstant. Lymphatics passing from superficial (inguinal) nodes to those deep in the iliac fossa.

(8) **Femoral ring.**—This is mainly an artificial product. It is the upper or abdominal opening of the femoral canal. *Shape:* oval, with its long axis transverse. It is larger in women. *Boundaries:* internally, the lacunar (Gimbernat's) ligament; externally, the femoral vein; in front, Poupart's ligament and the thickening of the transversalis fascia attached to it, and called 'the deep crural arch'; behind, the pectineus and the linea terminalis (ilio-pectineal line). It is closed by the septum crurale, which is a barrier of fatty connective tissue, continuous with the extra-peritoneal fatty layer, perforated by lymphatics passing from the superficial to the deep group.

Position of vessels around the ring.—Outside, the femoral vein; above, the epigastric vessels as they ascend from the external iliac vessels, pass close to the upper and outer aspect of the ring; immediately in front are the cord and spermatic vessels always to be remembered in this hernia in the male; towards the inner side there may be an unimportant anastomosis between the epigastric artery above and the obturator below.

If from dilatation of the above anastomosis the obturator artery comes off abnormally from the inferior (deep) epigastric, it will descend, and usually does so, close to the junction of the external iliac and common femoral vein, and thus to the outer, and so the safe, side of the ring (fig. 967, A). In a very few cases it curves more inwards, close to the lacunar (Gimbernat's) ligament, and thus to the inner side of the ring, and is then in great danger (fig. 967, B). In two out of every five cases the obturator arises from the deep epigastric. In about thirty-seven per cent. of the cases with such an origin the artery either crosses or courses along the inner side of the ring. (Cunningham.)

FIG. 967.—IRREGULARITIES OF THE OBTURATOR ARTERY. (After Gray.)


A
Deep circumflex iliac artery
External iliac artery
External iliac vein
Obturator foramen
Internal ring, with spermatic vessels cut short in it
Inferior epigastric artery
Lymphatic node in femoral ring
The obturator artery, given off from the external iliac with the inferior epigastric, descends to gain the obturator foramen, but at a safe distance from the femoral ring
B
The obturator artery, coming off from the inferior epigastric, takes a course so near to the femoral ring that it would very likely be divided by the bistoury introduced from without to divide the base of the lacunar ligament, the cause of the constriction

Course of femoral hernia.—At first this is downwards in the femoral canal. A pouch of peritoneum having been gradually, after repeated straining, coughing, etc., pushed through the weak spot, the femoral ring, further weakened perhaps, together with all the parts in the femoral arch, by child-bearing, some extra effort will force intestine or omentum into this pouch and thus form a hernia. Thus formed, femoral hernia passes at first downwards in the femoral canal as far as the fossa ovalis (saphenous opening), but, as a rule, does not go farther downwards on the thigh, but mounts forwards and upwards, and somewhat outwards, even reaching the level of Poupart's ligament. The reasons for this change of position are:—(1) The narrowing of the femoral sheath, funnel-like, i. e., wide above, but narrowed below; (2) the unyielding nature of the lower margin of the fossa ovalis (saphenous opening); (3) the fact that this margin and the outer border are united to the femoral sheath; (4) the constant flexion of the thigh; (5) the fact that vessels (chiefly veins) and lymphatics descend to the fossa ovalis (saphenous opening), the veins to join the saphenous vein and the lymphatics to join the deeper group; these descending vessels serve to loop upwards or suspend a femoral hernia, and thus prevent its further course downwards.

Coverings of a femoral hernia.—(A) **At the upper** or **femoral ring** it obtains peritoneum, extra-peritoneal fat, and septum crurale.

(B) **In the canal,** a coating of the femoral sheath.

(C) **At the external** or **superficial opening,** further coverings of cribriform fascia, skin, and superficial fascia are added.

Some of these may be deficient by the hernia bursting through them, or they may be matted together. Sir A. Cooper thought this especially likely to occur with the layer of femoral sheath and septum crurale, to which he gave the name of *fascia propria.*

Radical cure of femoral hernia.—The close proximity of the femoral vein always introduces difficulty in the introduction of the deep sutures for closure of the crural ring. Any closure below this point is certain to be inefficient. The safest and simplest method is to feel for the pulsation of the femoral artery, and make allowance for the vein on its inner side. The latter vessel is then protected by the finger-tip passed up the femoral canal, so that its dorsum rests against the vein and its tip upon the linea terminalis (ilio-pectineal line). The sutures are then passed so as to pick up the ilio-pectineal fascia and its thickened part, Cooper's ligament, below, and the deep crural arch and Poupart's ligament above (fig. 966). Thus, when tightened, they draw the anterior and posterior boundaries of the ring together. (Lockwood, Bassini.)

PARTS CONCERNED IN UMBILICAL HERNIA

A hernial protrusion at the umbilicus, or exomphalos, may occur at three distinct periods of life, according to the anatomy of the part. Any account of umbilical hernia would be incomplete without an attempt to explain how this region, originally a most distinct opening, is gradually closed and changed into a knotty mass of scar, the strongest point in the abdominal wall.

During the first weeks of fœtal life, in addition to the urachus, umbilical arteries, and vein, some of the mesentery and a loop of the intestine pass through the opening to occupy a portion of the body cavity situated in the umbilical cord, later on returning to the abdominal cavity. Occasionally this condition persists, owing to failure of development, and the child is born with a large hernial swelling outside the abdomen, imperfectly covered with skin and peritoneum. To this condition the term **congenital umbilical hernia** should be applied.

Later on in fœtal life it is the umbilical vessels alone which pass through this opening. At birth there is a distinct ring, which can be felt for some time after in the flaccid walls of an infant's belly. If this condition persist, a piece of intestine may find its way through, forming the condition which should be known as **infantile umbilical hernia.**

This condition is not uncommon. Why it is not more frequently met with is explained by the way in which this ring of infancy is closed and gradually converted into the dense mass of scar tissue so familiar in adult life. This is brought about—(1) by changes in the ring itself; (2) by changes in the vessels which pass through it.

(1) **Changes in the ring itself.**—The umbilical ring is surrounded by a sphincter-like arrangement of elastic fibres, best seen during the first few days of fœtal life, on the posterior wall of the belly. In older infants these fibres lose their elasticity, become more tendinous, and then shrink more and more. As they contract they divide, as by a ligature, the vessels passing through the ring, thus accounting for the fact that the cord, wherever divided, drops off at the same spot and without bleeding.

(2) **Changes in the vessels themselves.**—When blood ceases to traverse these, their lumen contains clots, their muscular tissue wastes, while the connective tissue of their outer coat hypertrophies and thickens. Thus, the umbilical vessels and the umbilical ring are, alike, converted into scar tissue, which blends together. This remains weak for some time, and may be distended by a hernia (infantile).

Finally, we have to consider the state of the umbilicus in adult life. The very dense, unyielding, fibrous knot shows two sets of fibres:—(1) Those decussating in the middle line; and (2) two sets of circular fibrous bundles which interlace at the lateral boundaries of the ring. The lower part of the ring is stronger than the upper. In other words, **umbilical hernia of adult life,** when it comes through the ring itself and not at the side, always comes through the upper part. In the lower three-fourths of the umbilicus the umbilical arteries and urachus are firmly closed by matting in a firm knot of scar tissue; in the upper there is only the umbilical vein and weaker scar. To the lower part run up the umbilical arteries and the urachus. Owing to the rapid growth of the abdominal wall and pelvis before puberty, and the fact that the urachus and the umbilical arteries, being of scar tissue, elongate

with difficulty, the latter parts depress the umbilicus by reason of their intimate connection with its lower half.

Owing to the usual exit of an umbilical hernia of adult life being through the upper part of the ring, the constricting edge in strangulation should be sought below and divided downwards. As pointed out by Mr. Wood, it is here that the dragging weight of the hernial contents and the weight of the dress tend to produce the chief results of strangulation. An incision here also gives better drainage if required.

Coverings of an umbilical hernia.—These, more or less matted together, are.—(1) Skin; (2) superficial fascia, which loses its fat over the hernia; (3) prolongation of scar tissue of the umbilicus gradually stretched out; (4) transversalis fascia; (5) extra-peritoneal fatty tissue; (6) peritoneum. If the hernia come through above the umbilicus, or just to one side, the coverings will be much the same; but, instead of the layer from the umbilical scar, there will be one from the linea alba.

Strangulated umbilical hernia of adult life.—In this, the most fatal of the strangulated herniæ ordinarily met with, the following are practical points in the surgical anatomy:—1. The coverings, including the sac, are always thin, at times so markedly so that the infra-peritoneal contents are practically subcutaneous. 2. The sac is multilocular, and one or more of its chambers may lie very deep. 3. The contents are numerous, viz., omentum, often voluminous and adherent, transverse colon, and later in the history, small intestine. 4. The contents are often adherent to the sac and each other, thus explaining the irreducibility. 5. The long duration of the presence of the transverse colon with its stouter walls accounts for the period, often prolonged, in which warning evidence of incarceration precedes that of strangulation. 6. The communciation with the peritoneal sac is direct, short, and during a prolonged operation, free. Infection is thus readily brought about.

THE BACK

Median furrow.—This is more or less marked according to the muscular development, lying between the trapezii and semispinales capitis (complexus), in the cervical region, and the sacro-spinalis (erectores spinæ) lower down. The lower end of the furrow corresponds to the interval between the spines of the last lumbar and the first sacral vertebræ. (Holden.)

Vertebral spines.—Those of the upper cervical region are scarcely to be made out even by deep pressure. That of the axis may be detected in a thin subject. Over the spines of the middle three cervical vertebræ is normally a hollow, owing to these spines receding from the surface to allow of free extension of the neck. The seventh cervical is prominent, as its name denotes. Between the skull and atlas, or between the atlas and axis, a sharp-pointed instrument might penetrate, especially in flexion of the neck.

Of the **thoracic spines,** the first is the most prominent, more marked than that of the last cervical; the third should be noted as on a level with the inner end of the scapular spine, and in some cases with the bifurcation of the trachea; that of the seventh with the lower angle of the scapula; that of the twelfth with the lowest part of the trapezius and the head of the twelfth rib. The obliquity and overlapping of the thoracic spines are to be remembered.

Of the **lumbar spines,** the most important are the second, which corresponds to the termination of the cord, and the fourth, which marks the highest part of the iliac crests and the bifurcation of the abdominal aorta. The lumbar spines project horizontally, and correspond with the vertebral bodies. The third is a little above the umbilicus.

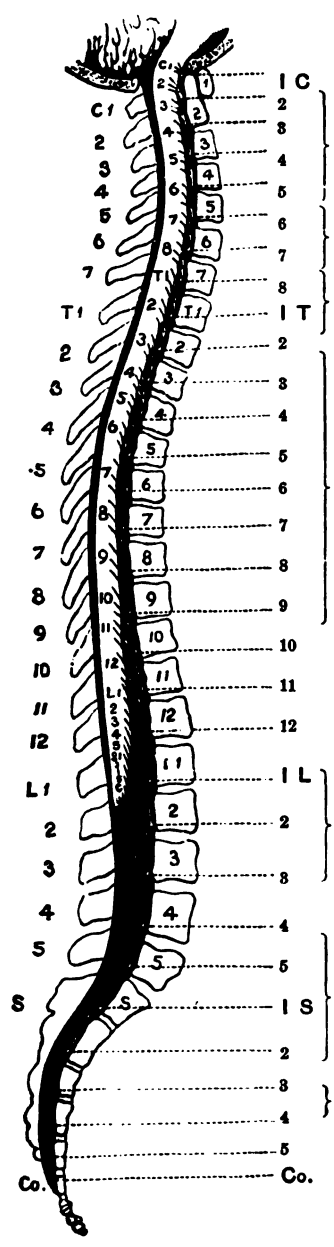
Owing to the obliquity of the thoracic spines, most of them do not tally with the heads of the corresponding ribs. Thus, the spine of the second corresponds with the head of the third rib; the spine of the third with the head of the fourth rib; and so on till we come to the eleventh and twelfth vertebræ, which do tally with their corresponding ribs. (Holden.)

The lower ribs may be left outside the sacro-spinalis (erector spinæ), but, in counting them from below, it must be remembered, as pointed out by Holl, that in quite a considerable percentage the last rib is so abnormally short that it does not reach as far as the outer border of the sacro-spinalis; or so rudimentary as to more resemble a transverse process. In these cases the lower end of the pleura may pass from the

lower part of the twelfth thoracic vertebra, almost horizontally to the lower edge of the eleventh rib (p. 1296).

Muscles.—The student will remember the greater number and complexity and the numerous tendons of the muscles which run up on either side of the spine; the firmness and inextensibility

FIG. 968.—DIAGRAM AND TABLE SHOWING THE APPROXIMATE RELATION TO THE SPINAL NERVES OF THE VARIOUS MOTOR, SENSORY, AND REFLEX FUNCTIONS OF THE SPINAL CORD. (Arranged by Dr. Gowers from anatomical and pathological data.)



	MOTOR	SENSORY	REFLEX
C 1	Sterno-mastoid, Trapezius	Neck and scalp	
2		Neck and shoulder	
3	Diaphragm		
4	Serratus, Shoulder	Shoulder	Scapular
5	Arm (musc.)	Arm	
6	Hand (ulnar lowest)	Hand	
7			
8			
T 1			
2	Intercostal muscles	Front of thorax	Epigastric
3		Xiphoid area	
4			
5			
6			
7			
8			
9	Abdominal muscles	Abdomen (Umbilicus 10th)	Abdominal
10			
11		Buttock, upper part	
12			
L 1	Flexors, hip	Groin and scrotum (front)	Cremasteric
2	Extensors, knee	Thigh (outer side, front, inner side)	*Knee-joint*
3	Adductors (hip)		
4		Leg, inner side	
5	Abductors	Buttock, lower part	Gluteal
S	Extensors (?)		
1	Flexors, knee (?)	Back of thigh	*Foot-clonus*
2	Muscles of leg moving foot	Leg and foot (except inner part)	Plantar
3			
4	Perinæal and anal muscles	Perinæum and anus	
5			
Co.		Skin from coccyx to anus	

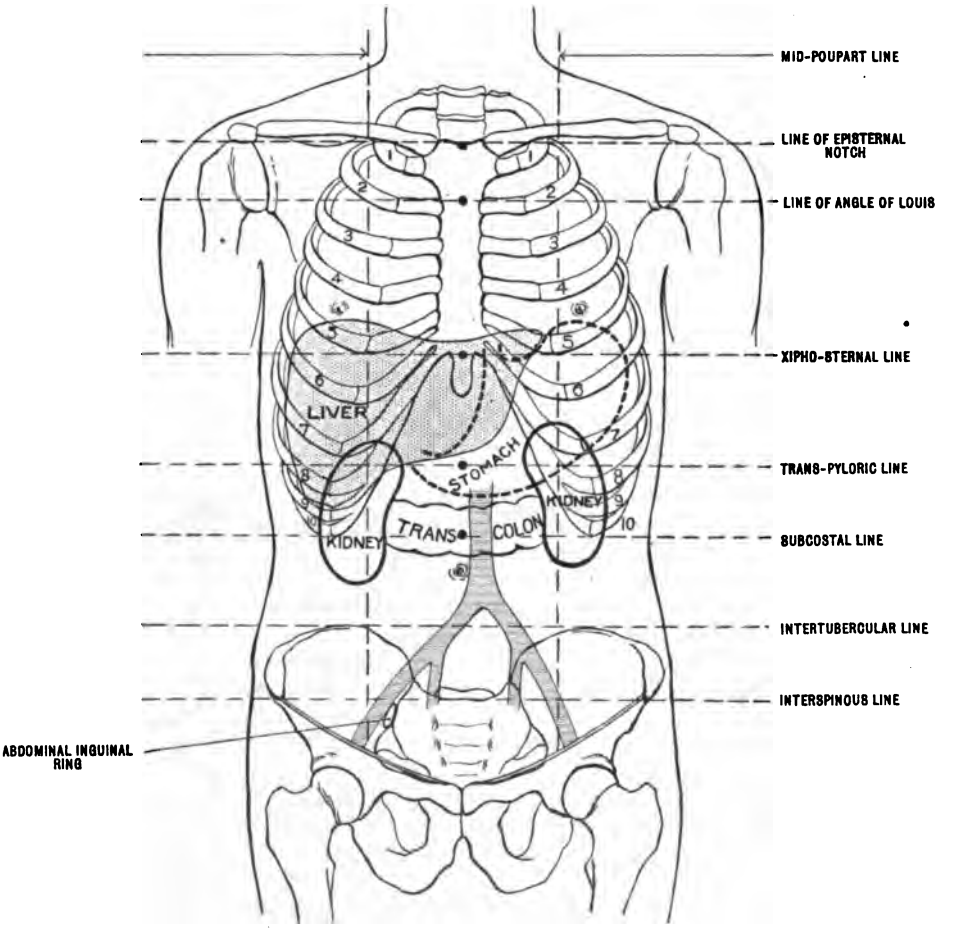
of their sheaths; the large amount of cellular tissue between them; and the fact that towards the nape of the neck these muscles lie exposed instead of being protected in gutters, as is the case below: all these anatomical points explain the extreme painfulness and obstinacy of sprains here.

Trapezius.—To map out this muscle, the arm should be raised to a right angle with the spine. The external occipital protuberance should be dotted in, and the superior nuchal line passing out from this; below, the twelfth thoracic spine should

be marked; and externally, the outer third of the clavicle and the commencement of the scapular spine. Then a line should be drawn from the protuberance vertically downwards to the twelfth thoracic spine; a second from about the middle of the superior nuchal line to the posterior and outer third of the clavicle; and a third from the last thoracic spine upwards and outwards to the root of the spine of the scapula.

Latissimus dorsi.—The arm being raised above a right angle, the spines of the sixth thoracic and the third sacral vertebræ should be marked; then the outer lip of the crest of the ilium, the lower two or three ribs, the lower angle of the scapula, and the posterior fold of the axilla, and finally the intertubercular (bicipital) groove should all be marked.

FIG. 969.—RELATIONS OF THE ABDOMINAL VISCERA TO THE ANTERIOR PARIETES. (Treves.)



A vertical line from the sixth thoracic to the third sacral spine will give the spinal origin of the muscle. Another from the third sacral spine to a point on the iliac crest, 2·5 cm. (1 in.) or more outside the edge of the sacro-spinalis (erector spinæ), will give the origin of the muscle from the sheath of the sacro-spinalis (erector spinæ) and the ilium. A line from the sixth thoracic spine, almost transversely at first, with increasing slight obliquity over the inferior angle of the scapula to the axilla and intertubercular (bicipital) groove, will mark the upper border of the muscle. Another very oblique line from the point of the iliac crest upwards and outwards to the axilla will give the lower border and the tapering triangular apex of the insertion. The muscle may be attached to the angle of the scapula, or separated from it by a bursa.

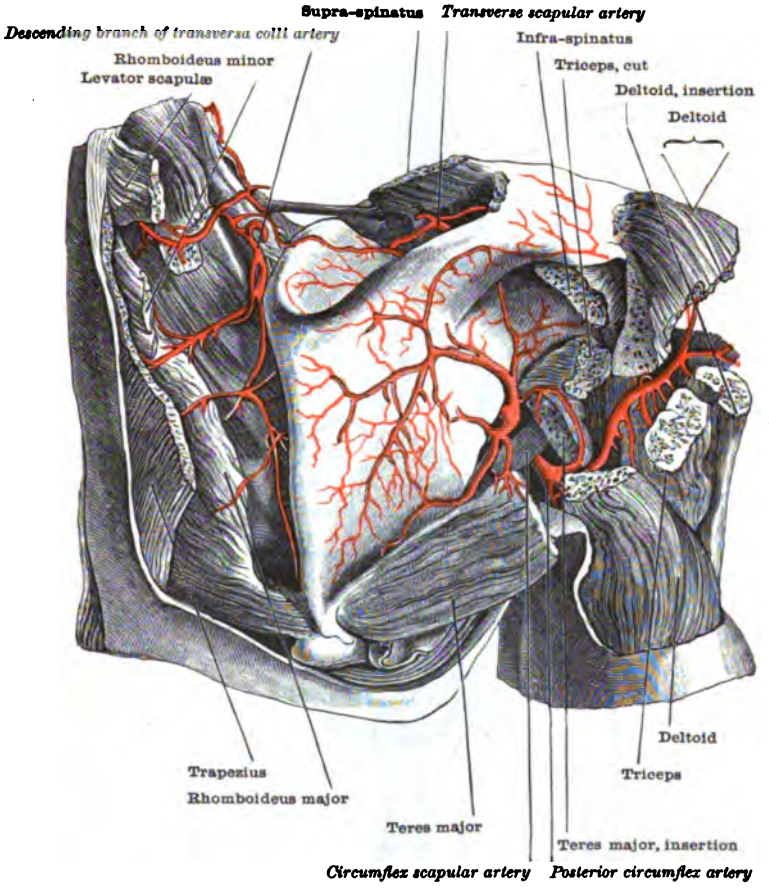
Triangle of Petit.—This small space lies above the crest of the ilium, at about

its centre, bounded by the anterior edge of the latissimus behind and the posterior border of the external oblique, in front. Through this gap, when the muscles are weak, a lumbar abscess occasionally, and very rarely, a lumbar hernia, may appear.

Origin of spinal nerves.—It is very important to remember the relations of these to the vertebral spines, in determining the results of disease or injury of the cord and the parts thereby affected. The above relations may be given briefly as follows:—

The origins of the eight cervical nerves correspond to the cord between the occiput and the sixth cervical spine. The upper six thoracic come off between the above spine and that of the fourth thoracic vertebra. The origins of the lower six thoracic nerves correspond to the interval between the fourth and the tenth thoracic

FIG. 970.—CHIEF ARTERIAL ANASTOMOSES ON THE SCAPULA.
(From a dissection in the Hunterian Museum.)



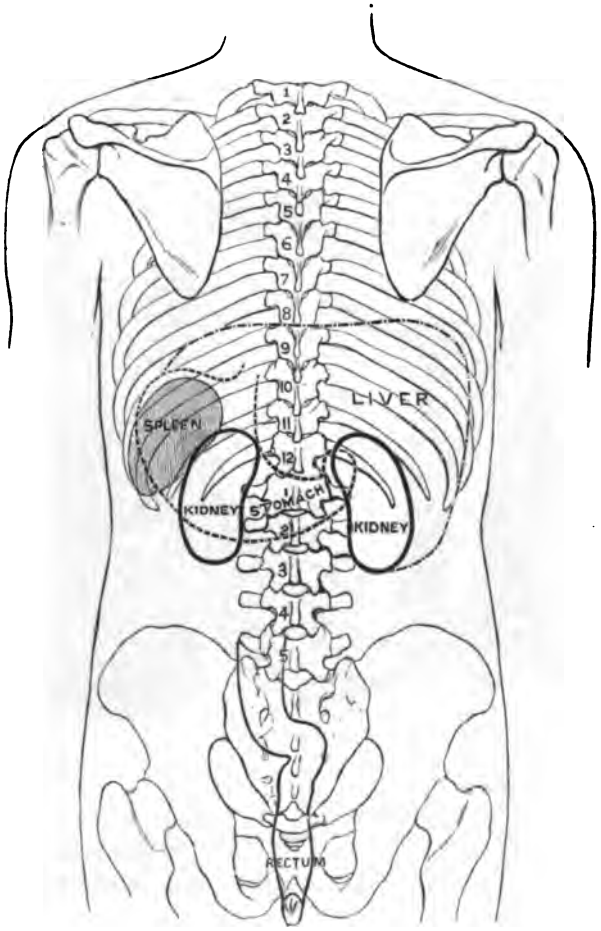
spines. The five lumbar arise opposite the eleventh and twelfth thoracic spines; and the origins of the five sacral correspond to the first lumbar spines. The diagram and table (fig. 968), arranged by Dr. Gowers from anatomical and pathological data, show the relations of the origins of the nerves to their exits from the vertebral canal, and the regions supplied by each.

Scapula, its muscles and arterial anastomoses.—Amongst the landmarks in the back, the student should be careful to trace the angles and borders of the scapula as far as these are accessible. The upper border is the one most thickly covered. With the hands hanging down, the upper angle corresponds to the upper border of the second rib; the lower angle to the seventh intercostal space; and the root of the spine of the scapula to the interval between the third and fourth thoracic spines. Fig. 970 shows the chief arteries around the scapula. The anas-

tomoses on the acromial process between the transverse scapular (supra-scapular) thoraco-acromial, and circumflex humeral arteries are not shown. The numerous **points of ossification,** primary and secondary, by which this bone is developed explain, in part, the frequency of cartilaginous and other growths here.

The anatomy of the loin behind, the ilio-costal region, is of prime importance, owing to the numerous operations here. **The outer border of the sacro-spinalis (erector spinæ) and quadratus lumborum** may be indicated on the surface thus. (Stiles.) That of the sacro-spinalis (erector) by drawing a line from a point on the iliac crest 8·2 cm. (3¼ in.) (four fingers'-breadth) from the middle line upwards and slightly outwards to the angles of the ribs. That of the quadratus passing upwards and slightly inwards lies a little external to that of the sacro-spinalis (erector) at the crest, and a little internal to it at the twelfth rib. The ascending and descending colon lie in the slightly depressed angle between the two muscles. The **ilio-costal region**

FIG. 971.—RELATIONS OF THE ABDOMINAL VISCERA TO THE POSTERIOR PARIETES. (Treves.)

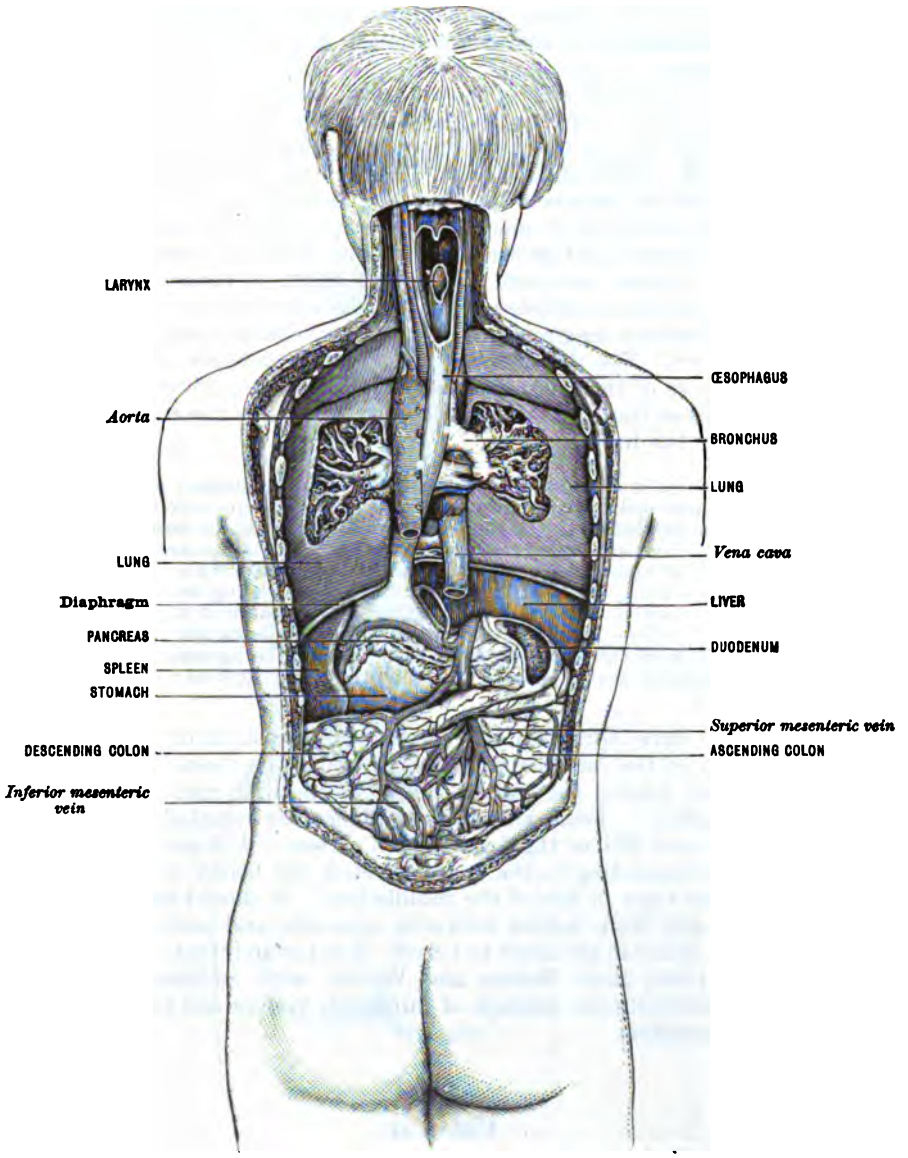


varies greatly in space according to the length of the lower ribs, shape of the chest, and development of the iliac crest. An incision here—that for exploration of the kidney may be taken as the type—would be an oblique one, about 10 cm. (4 in.) long, starting in the angle between the twelfth rib and the sacro-spinalis (erector spinæ) (p. 1330), and passing forwards and downwards towards the anterior extremity of the iliac crest. In its upper part the incision should lie 1·2 cm. (½ in.) below the twelfth rib. The anterior fibres of the latissimus dorsi are divided behind, the posterior ones of the external oblique in front. The yellowish-white lumbar fascia now comes into view, and is the first important landmark. It and the fibres of the internal oblique and transversalis which arise from it are next carefully divided. The last thoracic nerve and lowest intercostal artery may also require division. If the latter is cut close to the rib, the hæmorrhage is troublesome. The transversalis fascia remains to be divided. To avoid the peritoneum, the deeper part of the incisions should always be made from behind forwards. If more room is required, as in large growths or in exploration of the ureter, the incision must be prolonged beyond the iliac crest, the lumbo-ilio-inguinal incision of Morris.

Viscera.—Several of these, which can be mapped in behind—viz., the kidneys, spleen, etc.—have been already mentioned (pp. 1305, 1306). See also page 1305 for the incision for lumbar colotomy.

The commencement of the **trachea** and **œsophagus** has been given in front as corresponding to the fifth cervical vertebra. If examined from behind, this point, owing to the obliquity of the spines, would be a little lower down. The **trachea,** about 12·5 cm. (5 in.) long, descending in the middle line, bifurcates opposite to the

FIG. 972.—ABDOMINAL VISCERA, FROM BEHIND. (Rüdinger.)



interval between the third and fourth thoracic spines. The **bronchi** enter the lungs at about the level of the fifth thoracic spine, the right being the shorter, wider, and more horizontal. The **root of the lung.** This is opposite to the fourth, fifth, and sixth dorsal spines, midway between these and the vertebral border of the scapula. The structures in it are the bronchus, pulmonary artery, two pulmonary veins, bronchial vessels, lymphatics, and nerves. The phrenic nerve is in front, the posterior pulmonary plexus behind. On the *right* side the superior vena cava is in

front, the vena azygos (major) arching over the root at the level of the fourth thoracic vertebra. On the *left* side the aorta arches over the root, and the thoracic aorta descends behind it. The **œsophagus,** about 25 cm. (10 in.) in length, starting in the middle line, curves, twice to the left, at first gradually at the root of the neck; from this point it tends to regain the middle line up to the fifth thoracic vertebra; thence finally turns again, and more markedly to the left, and passes through the diaphragm opposite to the tenth, entering the stomach at the eleventh thoracic vertebra or the ninth or tenth thoracic spine. In the thorax this tube traverses first the superior, then the posterior, mediastinum. At two spots, i. e., its commencement and where it is crossed by the left bronchus, it presents narrowings. The relations of this tube to the pleuræ, pericardium, aorta, vagi, and thoracic duct are important in the ulceration of malignant disease and infected bodies, and in the passage of instruments.

The **aorta** reaches the left side of the vertebral column, with its arch just above the fourth thoracic spine, and thence descends on the front of the column, with a slight tendency to the left, to bifurcate opposite the fourth lumbar spine.

The spinal cord.—This, about 45 cm. (18 in.) long, extends from the foramen magnum to the junction between the first and second lumbar vertebræ. Up to the third month of fœtal life it reaches to the sacral end of the vertebral canal; later, owing to the more rapid growth of the bony wall, its lower limit is at birth opposite the third lumbar vertebra. The dura mater is continued, as a sheath, as low as the second sacral vertebra. It is anchored above to the upper cervical vertebræ and the foramen magnum, and below, as the filum terminale, to the periosteum of the coccyx. The deficiency of the spinous processes and laminæ of the fourth and fifth pieces of the sacrum allows of infection, e. g., of a bed-sore reaching the membranes, and so the cord. The arachnoid and pia of the cord are continuous above with those of the brain.

The parts of the spine most exposed to injury are the thoraco-lumbar and cervico-thoracic, partly because here more mobile parts are joined to those which are more fixed, and also from the amount of leverage exerted on the thoraco-lumbar region, and, in the case of the upper region, because this is affected by violence exerted on the head. *The chief provisions for protection of the cord* are the number of bones and joints which allow of movement without serious weakening, the three curves and columns, cervical, thoracic, and lumbar, ensuring bending before breaking; the large amount of cancellous tissue and the number and structure of the intervertebral discs all tending to damp vibrations; the large size of the theca vertebralis and the way in which the cord, anchored and slung by the thirty-one pairs of nerves and the ligamenta denticulata, about twenty in number, occupies neutral ground in the centre of the canal as regards injury directly and indirectly applied.

In **lumbar puncture** (Quincke) as a means of diagnosis or of relieving pressure advantage is taken of the fact mentioned above that the theca extends below the cord. A line drawn joining the highest points of the iliac crests crosses the fifth lumbar spine. (Tuffier.) From this spot the spines are counted and the interval between the fourth and fifth or third and fourth chosen. A finger being kept on the spinous process corresponding to the space selected, the needle is introduced about 6 mm. ($\frac{1}{4}$ in.) to the right or left of the middle line. It should be pushed onwards with a slight obliquity from behind forwards, upwards, and inwards for a distance varying from 5 cm. (2 in.) in the adult to 1·8 cm. ($\frac{3}{4}$ in.) in an infant.

The following table, from Holden and Windle, with additions, will be found very useful in determining the relation of numerous viscera and other structures to the bodies of the vertebræ

CERVICAL

First. Level of hard palate.

Second. Level of free edge of upper teeth.

Second and third. Superior cervical ganglion of sympathetic.

Fourth. Hyoid bone. Upper aperture of larynx.

Fifth. Thyreoid cartilage and rima glottidis. Between this and the last would be the bifurcation of the common carotid.

Sixth. Cricoid cartilage. Ending of pharynx and larynx. Consisting of the fused fifth and sixth ganglia, the middle cervical ganglion is usually opposite this vertebra. Here the omo-hyoid crosses the common carotid, and at this spot, the

seat of election, the centre of the incision for tying this vessel is placed. At this level the inferior thyreoid passes behind the carotid trunk.

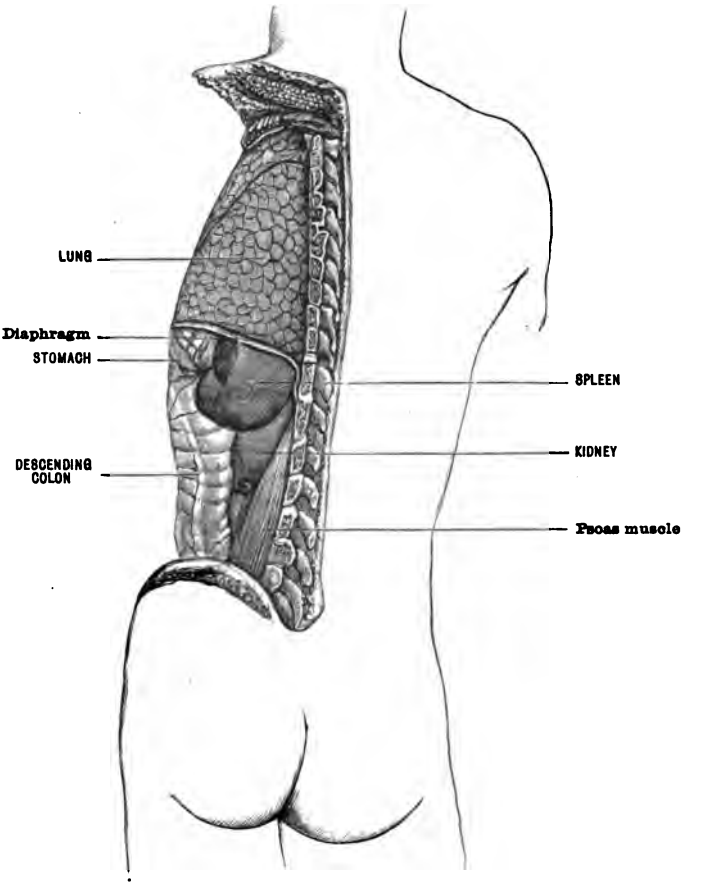
Seventh. Inferior cervical ganglion. Apex of lung. Arch of thoracic duct over apex of lung, outwards and downwards to termination.

Thoracic

First. Summit of arch of subclavian. (Godlee.) The height of this varies. Usually it is from 1·2 to 2·5 cm. (½ to 1 in.) above the clavicle. It is always in close relation with the cervical pleura.

Second. Level of episternal notch. This is usually opposite the fibro-cartilage between the second and third. Bifurcation of innominate. (Godlee.)

Fig. 973.—View of the Spleen, etc., from behind. (Rüdinger.)



Third. Bifurcation of trachea. Beginning of superior cava, at junction of first right costal cartilage with sternum. Highest part of aortic arch, about 2·5 cm. (1 in.) below notch.

Fourth. Second piece of aortic arch, extending from upper border of second right costal cartilage, reaches spine. Arch of vena azygos. The superior mediastinum is bounded behind by the upper four thoracic vertebræ. Louis' line of junction of manubrium and gladiolus. Thoracic aorta begins.

Fifth to eighth. Base of heart.

Sixth. Pulmonary and aortic valves, opposite third left costal cartilage at its

sternal junction, in front. Commencement of aorta and pulmonary artery. End of superior cava, third right chondro-sternal junction in front.

Seventh. Mitral orifice.

Eighth. Tricuspid orifice.

Ninth. Lower level of manubrium and sterno-xiphoid line (at lower border). Opening in diaphragm for inferior vena cava (lower border).

Tenth. Level of tip of xiphoid cartilage. Lower limit of lung posteriorly. Upper limit of liver comes to the surface posteriorly. Œsophagus passes through diaphragm. Cardiac orifice of stomach. Upper limit of spleen.

Eleventh. Lower border of spleen. Suprarenal capsule.

Twelfth. Lowest part of pleura. Aorta passes through diaphragm (lower border). Cœliac artery (lower border). Upper border of kidney.

Lumbar

First. Superior mesenteric arteries. Pancreas. Pelvis of kidney. Renal arteries. Transpyloric line. (Addison.)

Second. Spinal cord ends at junction of first and second. Third piece of duodenum. Receptaculum chyli. Lower end of left kidney (middle of body of vertebra).

Third. Umbilicus, opposite fibro-cartilage, between this and fourth. Lower end of right kidney, subcostal line, upper part. Umbilical line between this and fourth vertebra.

Fourth. Bifurcation of aortic arch. Highest part of iliac crest.

Fifth. Commencement of superior vena cava.

Sacral

Third. End of pelvic colon and beginning of first piece of rectum proper. Lower limit of spinal membranes.

Fifth. Reflexion of recto-vesical pouch of peritoneum 2·5 cm. (1 in.) above base of prostate.

Coccyx (tip). 2·5 cm. (1 in.) below this commencement of anal canal. Termination of filum terminale.

SUPERFICIAL ANATOMY OF THE UPPER LIMB

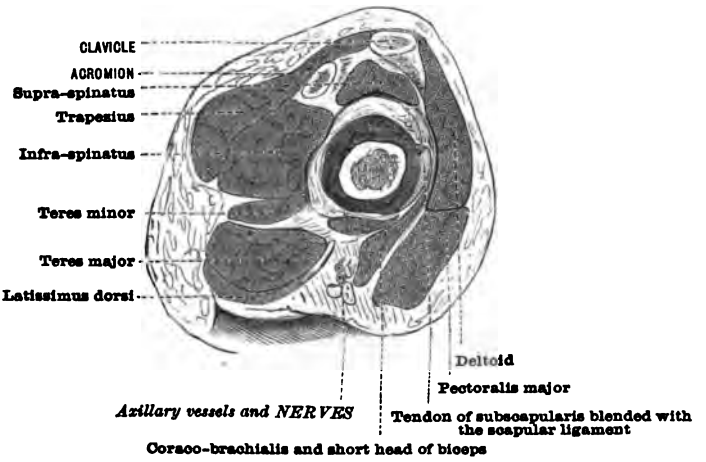
THE SHOULDER

The following **surface-marks,** of the greatest importance in determining the nature of shoulder injuries, can be made out here:—The **clavicle** in its whole extent, the **acromion process,** the **great tuberosity,** and **upper part of the shaft of the humerus.** Much less distinctly, the position of the **coracoid process** in the infraclavicular fossa and the **head of the humerus** through the axilla can be made out. The anterior margin of the **clavicle,** convex internally and concave externally, can be made out in its whole extent, the bone, if traced outwards, being found not to be horizontal, but rising somewhat to its junction with the acromion. The **sterno-** and **acromio-clavicular joints** have been referred to at pp. 1291, 1292. The *frequency of fracture of the clavicle* is explained chiefly by its exposure to shocks of varied kinds from the upper extremity, inseparable from the out-rigger-like action of the bone and its early ossification. On the other hand, *the main safeguards* are the elasticity and curves of the bone, the way in which it is embedded in muscles which will damp vibrations, and the buffer-bond fibro-cartilages at either extremity. The looseness and toughness of the overlying skin explain the rarity of compound fracture here. The junction of the two curves is the weakest spot and the usual site of fracture. The weight of the limb acting through the coraco-

clavicular ligaments and overcoming the trapezius is the chief factor in the downward displacement; the pectoralis minor and serratus anterior acting on the scapula draw the acromial fragment forwards. The tip of the acromion, when the arm hangs by the side, is in the same line as the external condyle and the styloid process of the radius. On the inner side, the head and internal condyle of the humerus and the styloid process of the ulna are in the same line. Thus the great tuberosity looks outwards, the head inwards, and the lesser tuberosity somewhat forwards. Between the two tuberosities runs the **intertubercular (bicipital) groove,** which, with the arm in the above position, looks directly forwards. In thin subjects its lower part can be defined. Its position can be marked with sufficient accuracy by a line running downwards from the acromion in the long axis of the humerus. Besides the tendon and its synovial sheath, the insertion of the latissimus dorsi, the humeral branch of the thoraco-acromial artery, and the anterior circumflex artery run in the groove. When the fingers are placed on the acromion and the thumb in the axilla, the lower edge of the glenoid cavity can be felt; and if the humerus be rotated (the elbow-joint being flexed), the head of the humerus can be felt also.

The **characteristic roundness of the shoulder** is due to the deltoid, supported by the head of the humerus and the tuberosities (fig. 975). In dislocation the loss of this roundness is due to the projection of the acromion. This normal projection

FIG. 974.—TRANSVERSE SECTION THROUGH THE RIGHT SHOULDER-JOINT, SHOWING THE STRUCTURES IN CONTACT WITH IT. (Braune.)



of the deltoid renders it impossible to place a flat straight body in contact with both the acromion and the external epicondyle at the same time (Hamilton's dislocation test). Below the junction of the outer and middle thirds of the clavicle, between the contiguous origins of the pectoralis major and deltoid, is the infraclavicular fossa, in which lie the cephalic vein, the deltoid branch of the thoraco-acromial artery, and a lymphatic node which may be involved in obstinate tuberculosis of the cervical groups. On pressing deeply here, the coracoid process can be made out if the muscles are relaxed, and the axillary artery compressed against the second rib.

On raising the arm and abducting it, the different parts of the **deltoid** can often be made out—viz., fibres from the lower border of the spine of the scapula, the outer edge of the acromion, and the outer third or more of the front of the clavicle; the characteristic knitting of the surface owing to the presence of fibrous septa continuous, alike, with the skin and the sheath of the muscle and the tendinous septa which separate the muscular bundles, will also be seen. The muscle will be marked out by a base-line reaching along the above bony points, and two sides converging from its extremities to the apex, a point on the outer surface of the humerus, about its centre. In paralysis of the deltoid, the humerus being no longer braced up against the scapula, the finger-tips can be placed between it and the acromion. To map out the **pectoralis major,** a line should be drawn down the lateral aspect of the

sternum as far as the sixth costal cartilage, and then two others marking the borders of the muscle—the upper corresponding to the deltoid, the lower starting from the sixth cartilage, and the two converging to the folded tendon, which is inserted as a double layer into the outer tubercular (bicipital) ridge. The **pectoralis minor** will be marked out by two lines, from the upper border of the third and the lower border of the fifth rib, just external to their cartilages, and meeting at the coracoid process. The lower line gives the level of the long thoracic artery; the upper, where it meets the line of the axillary artery, that of the thoraco-acromial.

When the arm is abducted and the humerus rotated a little outwards, the prominence of a well-developed **coraco-brachialis** comes into view; a line drawn from the centre of the clavicle along the inner border of this muscle to its insertion into the humerus gives the line of the axillary artery.

Axillary fossa.—The boundaries of this space anterior, posterior, inner, or thoracic, outer or humeral, apex and base, with the structures forming them and the vessels and nerves in relation to them, must be remembered. The chief vessels are the axillary on the outer wall, brought into prominence when the arm is abducted, as in removal of the mamma, and the subscapular on the posterior wall. The apex is felt, when the finger is pushed upwards in an operation here, to be bounded by the clavicle in front, the first rib behind, and the coracoid somewhat externally. The base is concave, owing to the coraco-clavicular (costo-coracoid) membrane as it descends to blend with the sheath of the pectoralis minor, giving also a process to the axillary fascia which unites the anterior and posterior boundaries. This process also sends septa to the skin.

An **axillary abscess,** always to be opened early to avoid subsequent interference with the movements of the shoulder, is reached by an incision on the inner wall, midway between the anterior and posterior boundaries, so as to avoid the long thoracic and subscapular vessels, respectively, the back of the knife being directed towards the outer wall. The only vessel on this wall is the superior thoracic, which lies high up. Additional safety is given by the use of Mr. Hilton's method. For **exploration** of the axilla the best incision is an angular one, the two limbs being placed in a line with the anterior margin of the great pectoral, and in the line of the axillary vessels. This runs from a point on the centre of the clavicle (the limb being at a right angle to the trunk) to the inner margin of the coraco-brachialis. If this be obliterated by swelling, the above line should be prolonged to the middle of the bend of the elbow, which will give the guide to the brachial also. **Collateral circulation.** If the first part of the artery be tied, the channels are the same as in ligature of the third part of the subclavian (*q. v.*). In ligature of the third part of the axillary, if the ligature be *above* the circumflex arteries, the chief vessels concerned are the transverse scapular (suprascapular) and thoraco-acromial above, and the posterior circumflex below. If the ligature be *below* the circumflex, the anastomoses will be those concerned in ligature of the brachial above the profunda (p. 1343). The lymphatic nodes in the axilla have been mentioned at p. 717.

The depression of the **axillary fossa** is best marked when the arm is raised from the side to an angle of about 45°, and when the muscles bounding it in front and behind are contracted. In proportion as the arm is raised, the hollow becomes less, the head of the humerus now projecting into it. When the folds are relaxed by bringing the arm to the side, the fingers can be pushed into the space so as to examine it.

The axillary (circumflex) nerve and posterior circumflex vessels wind around the humerus under the deltoid; a line drawn at a right angle to the humerus and a little above the centre of this muscle marks their position on the surface.

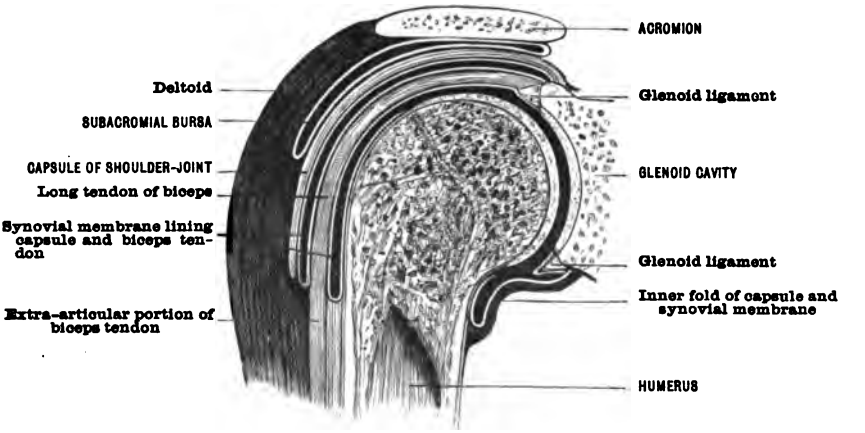
To trace the **synovial membrane of the shoulder-joint** is a comparatively simple matter (fig. 975). Covering both aspects of the free edge of the glenoid ligament, it lines the inner aspect of the capsule, whereby it reaches the articular margin of the head of the humerus; there is a distinct reflexion, below, from the capsule on to the humeral neck before the rim of the cartilage is reached. An extensive protrusion of synovial membrane takes place in the form of a synovial bursa, at the inner and anterior part of the capsule, near the root of the coracoid process under the tendon of the subscapularis. Another protrusion takes place between the two tuberosities along the intertubercular (bicipital) groove, as low as the insertion of the pectoralis major. A third synovial protrusion may be seen, but not frequently, at the outer or posterior aspect, in the form of a bursa, under the infra-spinatus tendon. Thus the continuity of the capsule is interrupted by **two** and **sometimes three synovial protrusions.**

Shoulder-joint.—The frequency of **dislocations** here, nearly equal to those of all the other joints put together, calls attention to the points contributing to make

the joint alike insecure and safe. **Strength** is given by (1) the intimate blending of the short scapular muscles, especially the subscapularis with the capsule; (2) the coraco-acromial vault; (3) atmospheric pressure; (4) the long tendon of the biceps; (5) the elasticity of the clavicle; (6) the mobility of the scapula. The **weakness of the joint** is readily explained by its free mobility, the want of correspondence between the articular surfaces, its exposure to injury, and the length of the humeral lever. The rent in the capsule is usually anterior and below, and to this spot the head of the humerus must be made to return. While dislocations are usually primarily subglenoid, owing to the above part of the capsule being the thinnest and least protected, they take usually a secondarily forward direction, as the triceps prevents the head passing backwards. In addition to the above features of the lower part of the capsule, laxity is here also a marked feature, to allow of free abduction and elevation. This movement will be accordingly much checked by any inflammatory matting of this part of the capsule. The **best incision for exploring the joint** is one commencing midway between the coracoid and acromion processes and carried downwards parallel with the anterior fibres of the deltoid. The cephalic vein and biceps tendon are to be avoided. If drainage is needed, it must be supplied by a counter-incision behind. This may be made along the posterior border of the deltoid, part of its humeral attachment being detached if necessary. The axillary (circumflex) nerve must be avoided in the upper part of the incision.

The **shaft of the humerus** is well covered by muscles in the greater part of

FIG. 975.—DIAGRAMMATIC SECTION OF SHOULDER THROUGH BICIPITAL GROOVE. (Anderson.)

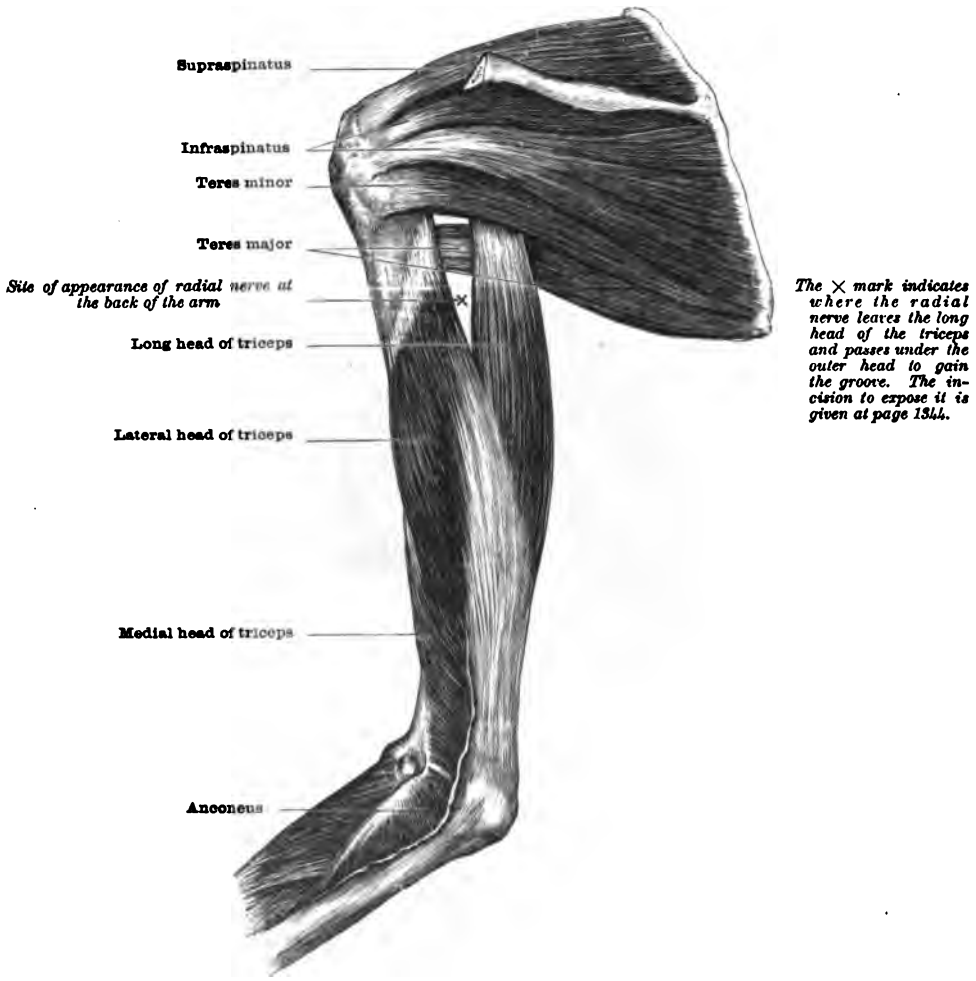


its extent, especially above. Below the insertion of the deltoid, the outer border of the bone can be traced downwards into the external supracondyloid ridge. The inner border and ridge are less prominent. Attached to these ridges and borders are the intermuscular septa, each lying between the triceps and brachialis anterior, and the outer one giving origin to the brachio-radialis (supinator longus) and extensor carpi radialis longus as well. The inner extends up to the insertion of the coraco-brachialis, the outer to that of the deltoid. The outer septum is perforated by the anterior part of the profunda vessels and the radial (musculo-spiral) nerve, the inner by the superior and posterior branch of the inferior ulnar collateral (anastomotica magna) artery and the ulnar nerve. The **biceps** has a two-fold attachment above and below. The former is of much importance in steadying the various movements, especially the upward one, and in harmonising the simultaneous flexion and extension of the shoulder- and elbow-joints. (Cleland.) The lacertus fibrosus curving downwards and inwards with its semilunar edge upwards, across the termination of the brachial artery, strengthens the deep fascia and the origin of the flexors of the forearm. The two heads unite in the lower third of the arm. The tendon, before its insertion, becomes twisted, the outer border becoming anterior. On either side of the well-known prominence of the biceps is a furrow. Along the outer ascends the cephalic vein. The inner corresponds to the line of the basilic vein which lies superficial to the deep fascia below the middle of the arm, and superficial and internal to the brachial vessels and median nerve.

The strength of such muscles as the deltoid, and their intimate connection with the periosteum of the humerus, account for fracture of this bone by muscular action being more common than elsewhere. The presence of muscular tissue between the fragments, together with deficient immobilization, explains the fact that ununited fractures are also most common in the humerus. **The best incisions for exploring the humerus,** e. g., in acute necrosis, etc., are (*a*) for *the upper portion,* the two already mentioned along the anterior and posterior borders of the deltoid. In the latter case the presence of the radial (musculo-spiral) nerve in the deeper part of the wound must be remembered; (*b*) for *the lower end* one parallel with the external intermuscular septum, deepened between the brachialis and brachio-radialis.

A line drawn along the inner edge of the biceps from the insertion of the teres major to the middle of the bend of the elbow corresponds to the **brachial artery.** In the upper two-thirds, this artery can be compressed against the bone by pressure outwards; in its lower third the humerus is behind it, and pressure should be made

FIG. 976.—BACK VIEW OF THE SCAPULAR MUSCLES AND TRICEPS.


Supraspinatus
Infraspinatus
Teres minor
Teres major
Site of appearance of radial nerve at the back of the arm
Long head of triceps
Lateral head of triceps
Medial head of triceps
Anconeus
The × mark indicates where the radial nerve leaves the long head of the triceps and passes under the outer head to gain the groove. The incision to expose it is given at page 1344.

backwards. The presence of the median nerve will interfere with any prolonged digital pressure applied in the middle of the arm. In **ligature of the artery** here the line is that for the axillary artery (p. 1340), prolonged to the centre of the front of the elbow. The only structures seen should be the inner edge of the biceps, the basilic vein, and the median nerve. The profunda comes off 2·5 cm. (1 in.) below the teres major, having the same relation to the heads of the triceps; thus, it first lies on the long head, behind the axillary and brachial arteries, then between the long and inner heads, and next, in the groove, between the inner and outer heads, and courses with the radial (musculo-spiral) nerve (fig. 978); the nutrient artery arises opposite the middle of the humerus; in many cases it arises, on the back of the arm, from the profunda; the superior ulnar collateral (inferior profunda) below the middle,

and courses with the ulnar nerve through the intermuscular septum to the back of the internal condyle. The inferior ulnar collateral (anastomotica magna) is given off from 2·5 to 5 cm. (1 to 2 in.) above the bend of the elbow. Fig. 982 will show the **collateral circulation** after ligature of the brachial, according as the vessel is tied above or below the superior profunda, or below the superior ulnar collateral.

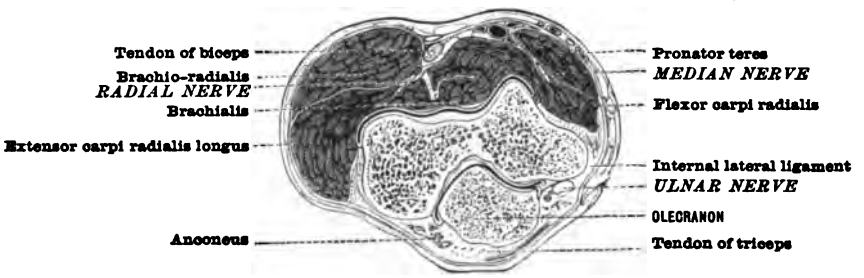
The **centre of the arm** is a landmark for many anatomical structures. On the outer side is the insertion of the deltoid; on the inner, that of the coraco-brachialis. The basilic vein and the medial brachial cutaneous nerve (nerve of Wrisberg) here perforate the deep fascia, going in reverse directions. The superior ulnar collateral (inferior profunda) is here given off from the brachial and joins the ulnar nerve; the median nerve also crosses the artery, and the ulnar nerve leaves the inner side of the vessel to pass to the inner aspect of the limb.

The **brachialis** can be mapped out by two pointed processes which surround the insertion of the deltoid, pass downwards into lines corresponding to the two intermuscular septa, and then converge over the front of the elbow to their insertion into the coronoid process.

The **median nerve** (outer head, 5th, 6th, 7th C.; inner head, 8th C. and 1st D.) can be traced by a line drawn from the outer side of the third part of the axillary and first part of the brachial artery, across this latter vessel about its centre, and then along its inner border to the forearm, where it passes between the two heads of the pronator teres.

The **ulnar nerve** (8th C. and 1st D.) lies to the inner side of the above arteries

FIG. 977.—HORIZONTAL SECTION OF THE ELBOW. (One-half.) (Braune.)



as far as the middle of the arm, where it leaves the brachial to course more inwards and perforate the internal intermuscular septum together with the superior and posterior branch of the inferior ulnar collateral and so get to the back of the internal condyle. A line drawn from the inner border of the coraco-brachialis, where, in the upper part of its course, the nerve is in close relation with the inner side of the axillary and brachial arteries, to the back of the internal condyle, will indicate its course. Low down, the nerve is in the inner head of the triceps, and may be injured in operations here.

The **radial (musculo-spiral) nerve** (5th, 6th, 7th, and 8th C.) can be traced by a line beginning behind the third part of the axillary artery, then carried vertically down behind the uppermost part of the brachial, and then, just below the posterior border of the axilla, curving backwards behind the humerus and slightly downwards, just below the insertion of the deltoid. Thus, passing from within outwards and from before backwards in its groove, accompanied by the profunda vessels, first the trunk, and then the smaller anterior division, it again comes to the front by perforating the external intermuscular septum at a point about opposite to the junction of the middle and lower thirds of the arm, and passes down in front of the external supracondyloid ridge, lying here between the brachio-radialis and brachialis anterior, to the level of the external condyle, in front of which it divides into the superficial (radial) and deep (posterior interosseous) radials. The former of these accompanies the radial artery to the front of the arm, the latter travels backwards to the back of the forearm. A line from the external condyle to the insertion of the deltoid indicates the external intermuscular septum.

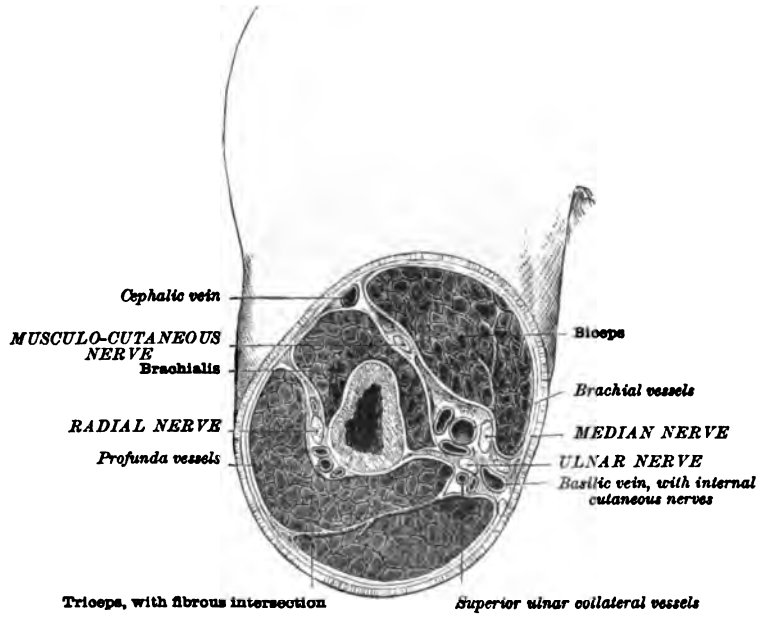
In addition to causes from fracture (p. 1342), the nerve may be injured in crutch pressure, the sleep of intoxication, use of an Esmarch's bandage, or the careless reduction of a dislocated

shoulder with the foot in the axilla. To expose the nerve the incision begins below, over the external intermuscular septum, where it lies between the brachio-radialis and brachialis anterior. Hence the incision is prolonged freely upwards and backwards towards the posterior border of the deltoid.

On the back of the arm is the **triceps muscle,** with its three heads and tendon of insertion, all brought into relief in a muscular subject when the forearm is strongly extended. Of the three heads, the inner is the least distinct, arising below the groove (musculo-spiral) for the radial (musculo-spiral) nerve, reaching to each intermuscular septum, and tapering away above as high as the teres major. Most of the fibres of this head lie deeply. The outer head, arising above the groove as high as the great tuberosity, appears in strong relief just below the deltoid; while the middle or long head, arising from the scapula just below the glenoid cavity, appears between the teres muscles. The tendon of insertion, passing into the upper and back part of the olecranon over a deep bursa, is shown by a somewhat depressed area. On the outer side, an important expansion to the fascia over the anconeus is given off.

In the ossification of the humerus the epiphyses are of first importance. The **upper,** consisting of those for the head and two tuberosities, which form one about the seventh year,

FIG. 978.—SECTION THROUGH THE MIDDLE OF THE RIGHT UPPER ARM. (Heath.)



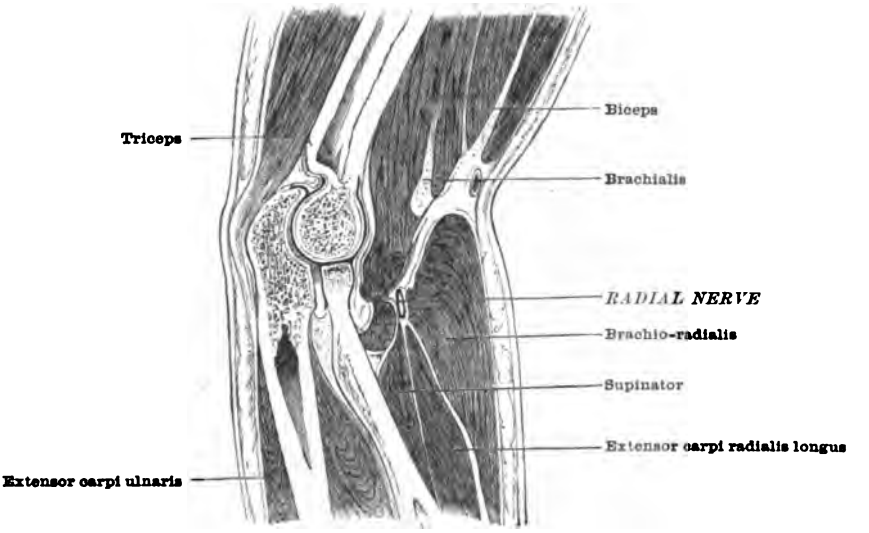
blends with the shaft between the twentieth and twenty-fifth years. Separation usually takes place at an earlier date, this being explained by the fact that the cone-like arrangement by which the diaphysis fits into the cap of the epiphysis becomes more marked towards the date of union, and thus tends to prevent displacement. (Thomson.) The **lower epiphysis.** The condition of this varies with the degree of coalescence of its four centres. The first and chief, that for the capitulum (second year), unites with those for the trochlea and external epicondyle soon after puberty, and forms an epiphysis which joins with the shaft at about sixteen. The epiphysis for the internal epicondyle appears at the fifth year and unites with the shaft at the eighteenth. Injury to this epiphysis may damage the ulnar nerve and open the elbow-joint. Thus, at and after puberty, there are two chief epiphyses to remember here:—(*a*) the larger, consisting of capitular, trochlear, and external epicondyle centres. This is almost entirely intra-articular; (*b*) the smaller, that for the internal epicondyle; the extent to which this is intra-articular varies. The structures that would be divided in **an amputation at the centre of the arm** are shown in fig. 978. The chief points needing attention are:—(1) To leave as much of the lever of the humerus as possible; (2) clean section of the large nerves, the radial (musculo-spiral) in its groove being especially liable to be frayed by the saw; (3) the difference between the amount of retraction of the free biceps in front, and the triceps behind, fixed to the bone and septa.

THE ELBOW

The **bony points,** epicondyles, olecranon, and head of radius, and their relation to one another, should be carefully studied. The internal epicondyle is the more

prominent of the two, is directed backwards as well as inwards, and lies a little above its fellow. Above it can be traced upwards the supracondyloid ridge and corresponding septum (p. 1341). The external epicondyle is more rounded, and thus less prominent; below, and a little behind it, the head of the radius can be felt moving under the capitulum when the forearm is supinated and flexed. A depression marks this spot and corresponds to the interval between the anconeus and brachio-radialis and extensor carpi radialis longus; at the back, the upper part of the olecranon is covered by the triceps. The lower is subcutaneous, and separated from the skin by a bursa. If the thumb and second finger be placed on the epicondyles and the index on the tip of the olecranon, and the forearm completely extended, the tip of the olecranon rises so as to be on the line joining the two epicondyles. In flexion at a right angle, the olecranon is below the line of the epicondyles, and in complete flexion quite in front of them. Between the inner epicondyle and olecranon is a pit, in which lie the ulnar nerve and the anastomosis between the inferior ulnar collateral (inferior profunda) and the posterior ulnar recurrent arteries. The coronoid process is so well covered by muscles, vessels, and nerves that its position cannot be distinctly made out.

FIG. 979.—LONGITUDINAL SECTION OF THE ELBOW-JOINT. (One-half.) (Braune.)

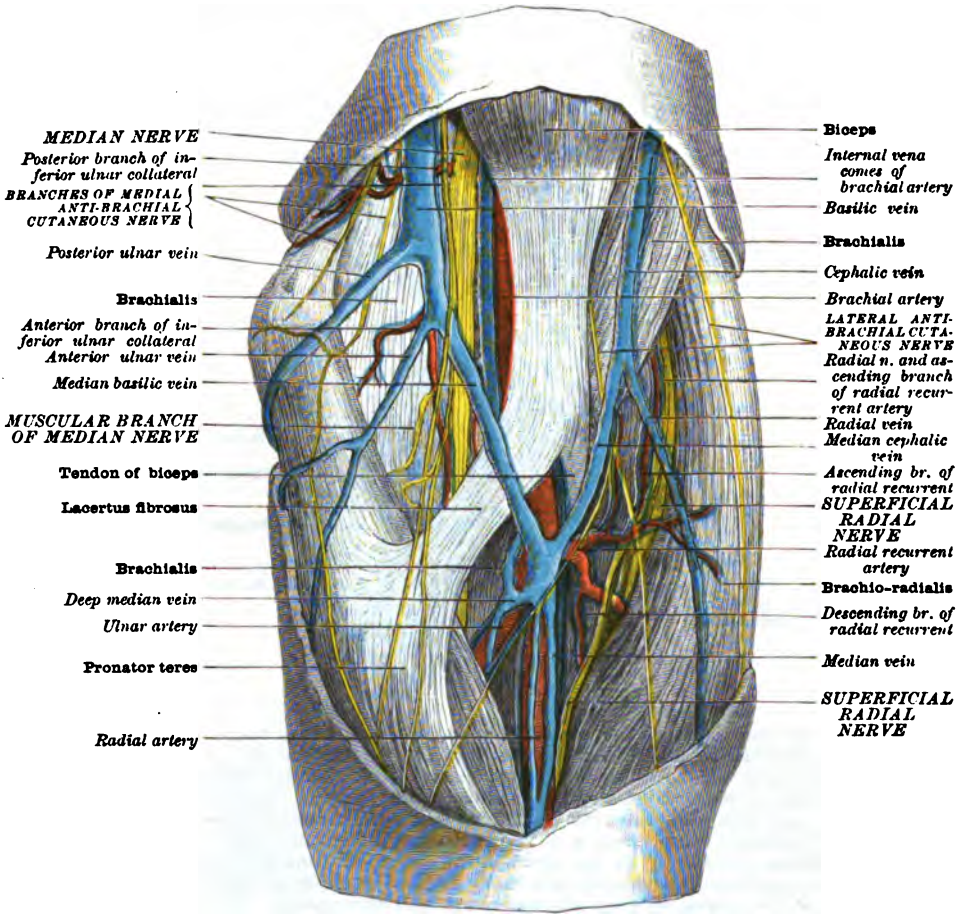


The synovial membrane of the elbow-joint communicates with that of the superior radio-ulnar. Hence the facility with which tuberculous disease may be set up after neglected falls on the hand, in early life. At this time the weakness of the annular (orbicular) ligament leads to its being easily injured. Swelling, due to effusion into the joint, appears on either side of the triceps tendon, and soon obliterates the depression below the external epicondyle. The simplest incision for an infected elbow-joint is a vertical one, on the outer side of the olecranon. A superficial swelling over the tip of the olecranon is due to effusion into the bursa between the soft parts and that bone. A deeper, less easily defined swelling in the same region is due to inflammation of the bursa between the olecranon and the triceps. A swelling on the inner side of the elbow-joint, if painful and accompanied by inflammation of the skin, may be due to mischief in the **epitrochlear lymphatic node** situated just above the internal epicondyle, and receiving lymphatics from the inner border of the forearm and the two inner fingers.

The hollow in front of the elbow.—The delicacy of the skin here must always be borne in mind in the application of splints. Owing to the insidious rapidity with which pressure may set up ischæmic paralysis, anterior angular splints are always to be used with caution. The **M-like arrangement of the superficial veins** as usually described is by no means constant (fig. 980). The median basilic is the vein usually chosen for venesection, owing to its larger size and its being firmly supported by the subjacent bicipital fascia which separates it from the brachial artery; but the median cephalic is the safer. The median basilic is crossed by branches of the medial antibrachial (internal) cutaneous nerve, while those of the

musculo-cutaneous lie under the median cephalic. In the semiflexed position, the fold of the elbow is seen, a little above the level of the joint. This forms the base of the triangular fossa below the elbow, the outer side corresponding to the brachio-radialis, the inner to the pronator teres, and the apex to the meeting of these muscles. The tendon of the biceps can be easily made out in the centre of the fossa, giving off above the lacertus fibrosus from its inner side to fasten down the flexors of the forearm. Under the tendon on its inner side lie the brachial artery and the median nerve, a little internal to it, for a short distance. The radial nerve (musculo-spiral) lies outside the fossa, between the brachio-radialis and the brachialis anterior, and gives off its two terminal branches in front of the external epicondyle. The brachial usually bifurcates opposite to the neck of the radius.

FIG. 980.—THE BEND OF THE ELBOW WITH THE SUPERFICIAL VEINS.
(From a dissection by Dr. Alder Smith in the Museum of St. Bartholomew's Hospital.)



The **arterial anastomoses about the elbow-joint** are as follows: The radial recurrent runs up under cover of the brachio-radialis to anastomose with the anterior branch of the profunda **on the front of the external condyle.** The posterior interosseous recurrent ascends, between the supinator and the anconeus, to anastomose **on the back of the external condyle** with the posterior branch of the profunda. It further joins, by a large anastomotic arch across the back of the joint, with the inferior ulnar collateral (anastomotica magna) and posterior ulnar recurrent. The anterior ulnar recurrent passes upwards on the brachialis to join the anterior part of the inferior ulnar collateral (anastomotica magna) under the pronator teres, on the front of the internal epicondyle. The posterior ulnar recurrent

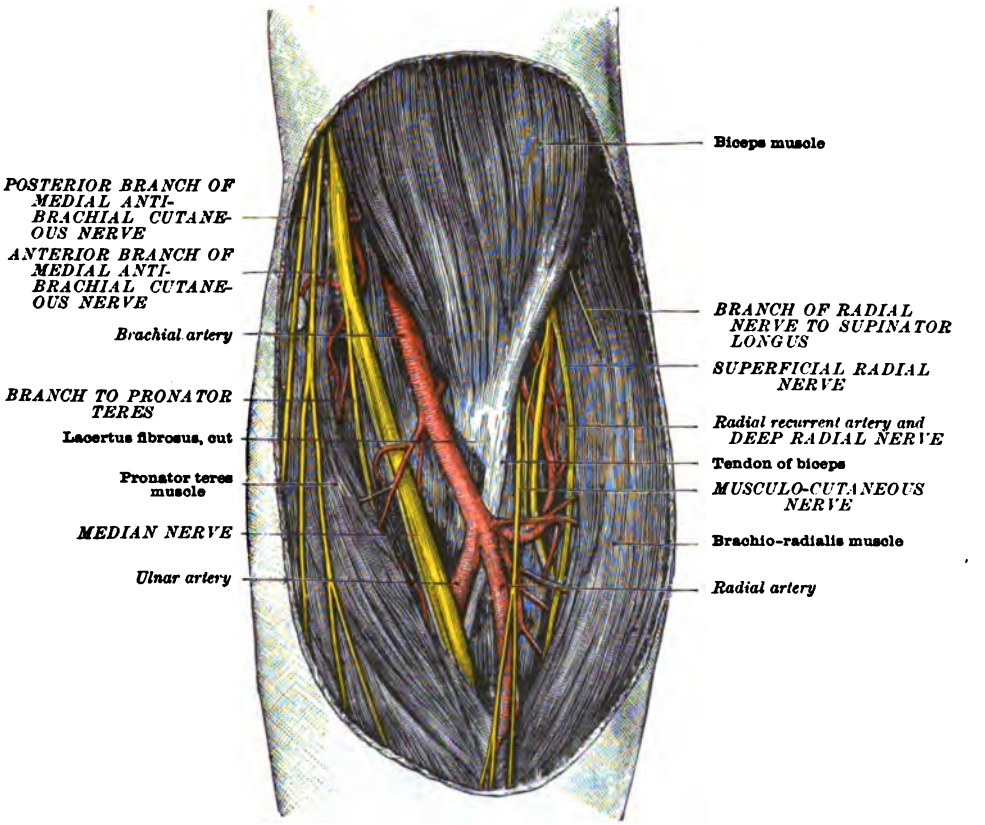
makes for the interval between the **back of the internal epicondyle** and the olecranon, to join with the superior and the posterior branch of the inferior ulnar collateral (anastomotica magna).

It will be seen that the inferior ulnar collateral (anastomotica magna) is the artery most largely employed, distributing branches everywhere, save to the front of the external epicondyle.

THE FOREARM

Bony landmarks.—The posterior border of the ulna can be easily traced down from the olecranon to the back of the styloid process; the bone becomes somewhat rounded below, and lies between the flexor and extensor carpi ulnaris. The tip of the styloid process corresponds to the inner end of the line of the wrist-joint. The

FIG. 981.—THE BRACHIAL ARTERY AT THE BEND OF THE ELBOW.
(From a mounted specimen in the Anatomical Department of Trinity College, Dublin.)

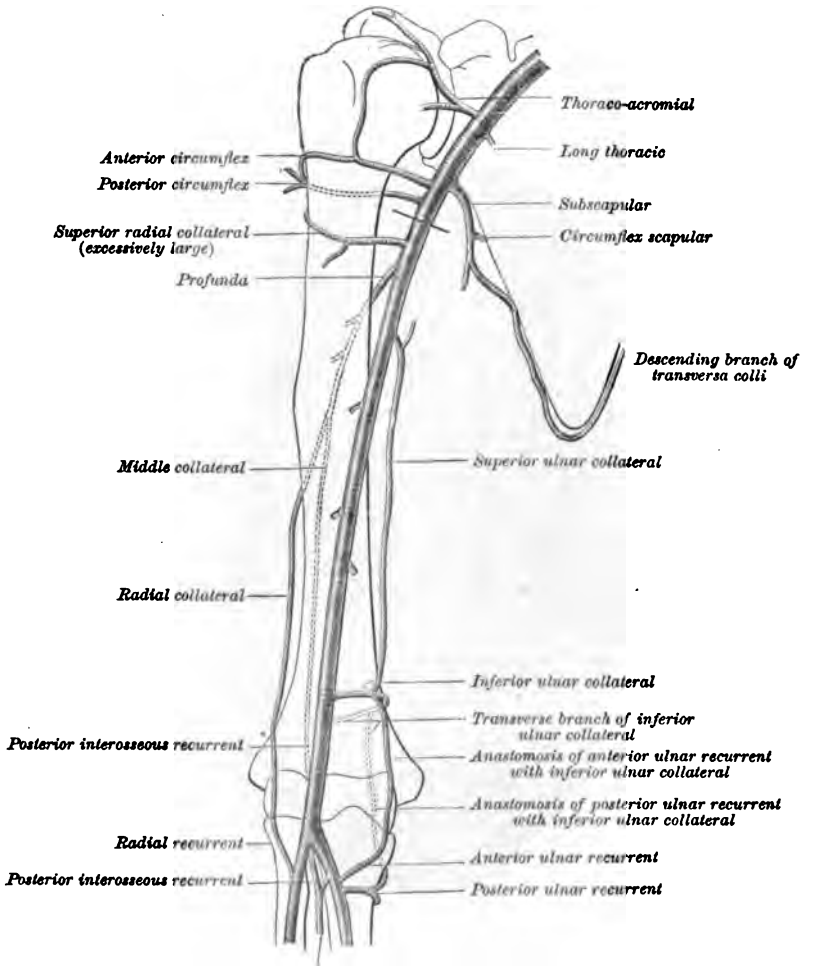


radius is covered above by the brachio-radialis and radial extensors of the carpus, and the outline of the bone is less easily followed. Its styloid process is readily made out below a finger's breadth above the thenar eminence. It is placed about 1·2 cm. (½ in.) lower than that of the styloid process of the ulna. Thus, a line drawn straight between the two processes would fall a little below that of the wrist-joint, this being shown by a line drawn between the two processes forming a slight curve, with its concavity downwards (corresponding to the concavity of the lower surface of the radius and fibro-cartilage) about 12 mm. (½ in.) above the straight line given above.

The radial styloid process is covered by the abductor longus and extensor brevis pollicis, while farther out lies the extensor pollicis longus. Between the styloid process of the ulna and the rounded head is the groove for the extensor carpi ulnaris. The bones are nearest to each other in complete pronation, and farthest apart in com-

plete supination. On section, the bones are found at every point nearer to the back than to the front of the limb, but increasingly so above. 'The lower the section proceeds down the limb, the less will the bones be covered at the sides, and the more equally will the soft parts be distributed about the anterior and posterior aspects of the limb. It will be noticed that where one bone is the more substantial, the other is the more slender, as near the elbow and wrist; and that it is about the centre of the limb that the two are most nearly of equal strength.' (Treves.) When the limb is pronated, the interosseous space is narrowed; in supination and the mid-position it is widened out. In pronation, both styloid processes can be distinctly made out;

FIG. 982.—DIAGRAM OF THE ANASTOMOSES OF THE BRACHIAL ARTERY. (MacCormac and Anderson.)

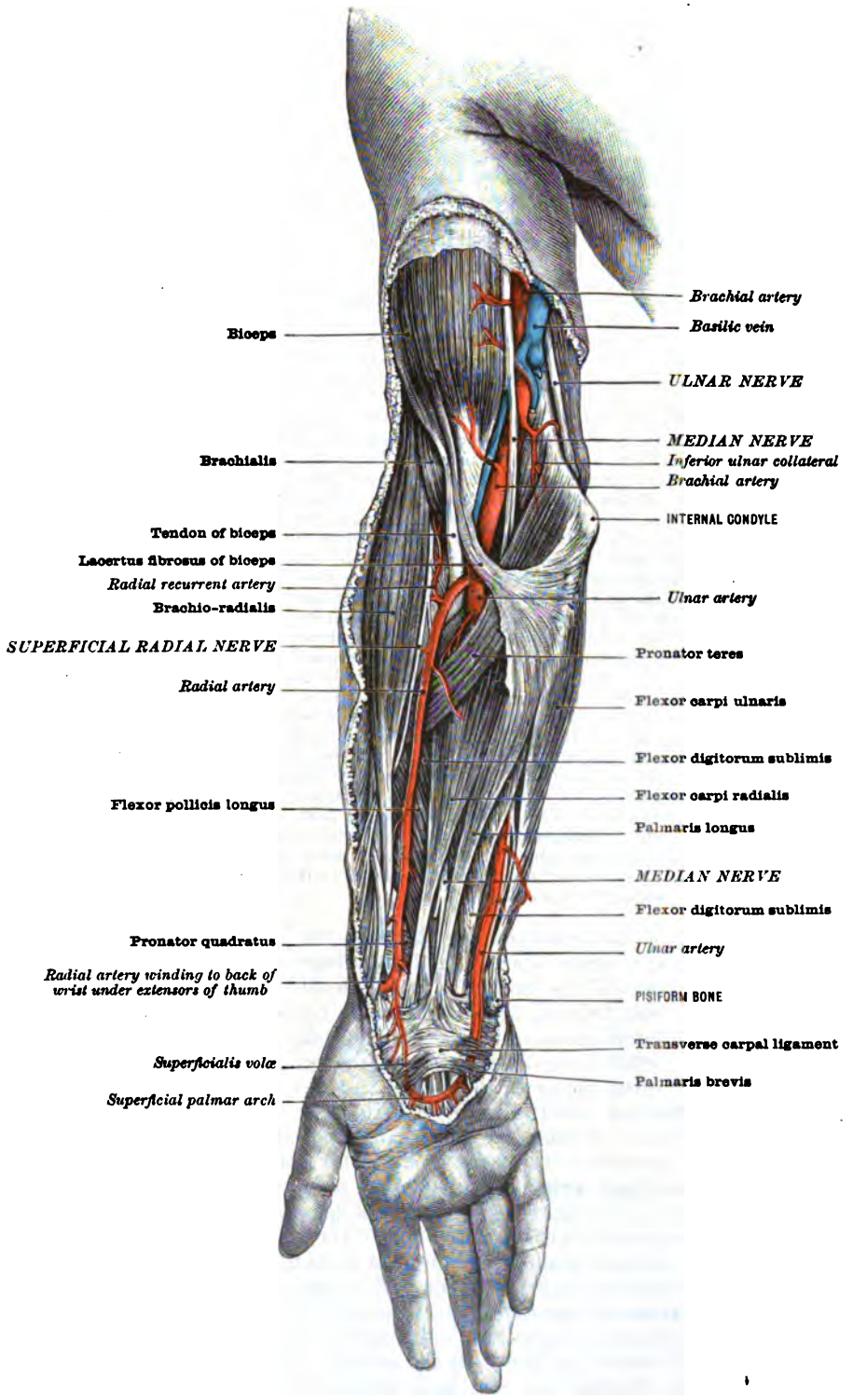


in supination, that of the radius is the more distinct, as now the skin and soft parts are stretched and raised over that of the ulna.

Joints.—The position of the **superior radio-ulnar joint** is marked by a dimple about 18 mm. ($\frac{3}{4}$ in.) below the external epicondyle. The **inferior** can just be felt, when the forearm is pronated, between the head of the ulna and lower end of the radius. The recessus sacciformis here may be enlarged in rheumatic and other affections. The **interosseous membrane** not only ties the bones together and gives attachment to muscles, but in falls on the hand it enables the ulna to participate in the shock.

The following are important points with regard to **the bones.** *Common fractures. Olecranon.*—This may take place at three sites, the constricted centre of the semilunar (greater sigmoid)

FIG. 983.—THE ARTERIES OF THE FOREARM WITH THE SUPERFICIAL PALMAR ARCH.



notch and the junction of the group with the shaft. A fall is here the usual cause, and the heavier the fall, the more frequently is the fracture nearer the shaft, though displacement is now likely to be slight, owing to the abundance of fibrous and muscular structures on both sides of the fracture. *The shaft of one or both bones.* Usual site, about the middle or a little below it, fracture of the radius being more frequent from its more exposed position and connection with the hand. In these fractures the chief muscular agencies are—(1) the extensors and flexors in drawing the lower fragment or fragments upwards, forwards, or backwards, according to the direction of the fracture; (2) the biceps in drawing the upper fragment of the radius upwards; (3) the influence of the pronator teres, if the fracture is, as usual, below it, and (4) that of the quadratus in drawing the lower fragments together. Thus the chief practical points are—(*a*) the reduction of displacement, whether antero-posterior or lateral; (*b*) the greater the number of fragments, the greater the tendency to union across the interosseous space, with its embarrassing results, and the greater the need of a supinated position in the setting; (*c*) the risk of gangrene here from the facility with which the vessels are compressed against the contiguous bones, especially in flexion of the forearm; and the consequent need of attention to the width of the splints and the bandaging; (*d*) the readiness with which ischæmic paralysis may rapidly and insidiously be caused. **Colles' fracture.** Here, after a fall on the hand, the radius gives way usually at its weakest part, about 18 mm. (¾ in.) above its extremity, where the narrow compact tissue is suddenly expanding into cancellous. There is frequently impaction of the upper into the lower fragment. There is a three-fold displacement of the lower fragment:—(1) It is driven and drawn upwards and backwards. (2) It is rotated so that its articular surface looks somewhat backwards. (3) It is drawn to the radial side. The chief causes of the discreditable stiffness often allowed to result are non-reduction of the deformity, adhesions in the opened wrist-joint, teno-synovitis, and constitutional conditions.

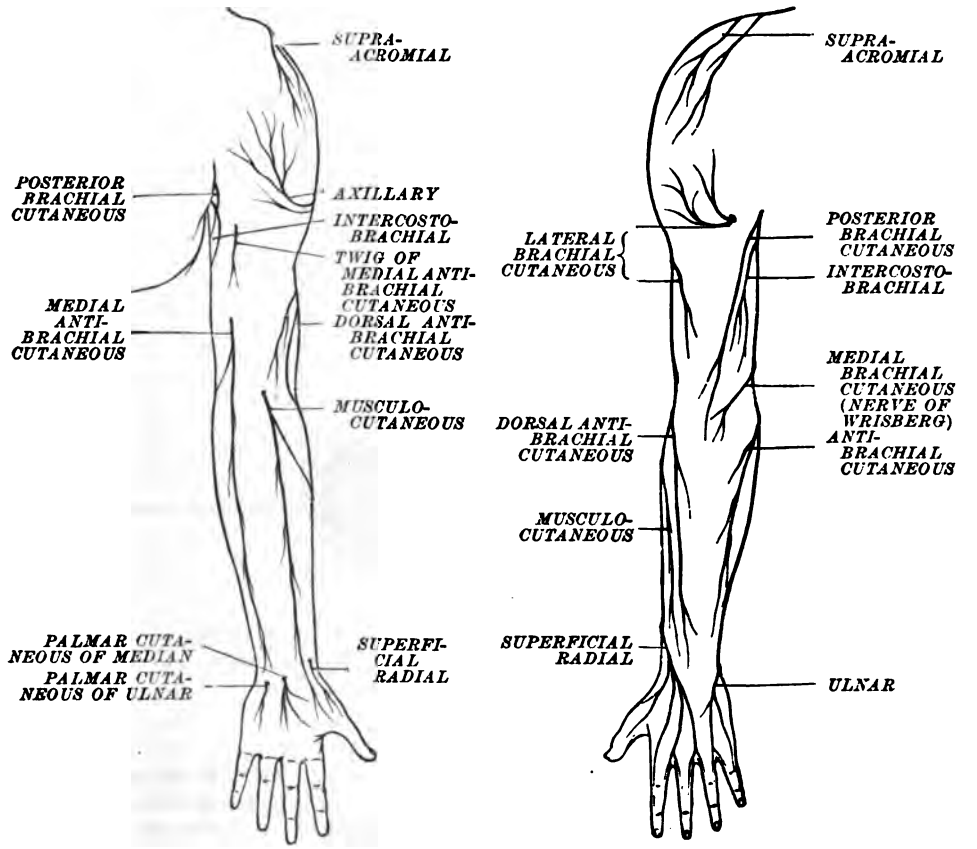
Separation of epiphysis.—This may take place in the **radius** up to about the age of eighteen: it is commoner before. Its possible importance in interfering with the symmetry of the growth of the bones is obvious. Here, as in Colles' fracture, the level of the styloid processes of the radius and ulna, and the correspondence of the two styloid processes of the radii, are important in diagnosis. **Exposure of the bones.** In the case of ununited fracture or necrosis the **radius** may be reached—(*a*) *Behind*, by an incision in a line drawn from the external epicondyle to the back of the radius. The field opened here lies between the brachio-radialis and the radial extensors on the one side, and the common extensor on the other. Care must be taken of the deep radial (posterior interosseous) nerve. (*b*) *In front.* The incision here lies in the sulcus between the brachio-radialis and the flexors. The pronator teres and the flexor sublimis must, in part, be detached from the radius. If more room is required to reach an injured upper extremity of the radius, the incision will descend from above the external epicondyle in the groove between the anconeus and common extensors. In the detachment of the supinator the deep radial (posterior interosseous) nerve will again need attention. The **ulna** is more easily reached by an incision between the flexor and extensor carpi ulnaris. In removal of the lower part of the bones for myeloid sarcoma or osteitis, the ulna is reached in the interval last mentioned. The radius is best exposed by an incision between the brachio-radialis and extensor carpi radialis longus, the superficial radial (radial) nerve being the guide. (Morris.) Finally, the so-called 'carrying angle' of the forearm deserves mention. In extension the bones of the forearm are not in a straight line with the humerus, but directed slightly outwards, the angle at the elbow-joint being obtuse, and open outwards. This angle is so named from its facilitating carrying objects during walking. In flexion the forearm is deflected somewhat inwards towards the middle line, mouth, etc. These properties are liable to be lost under many and widely different conditions, of which injuries to the epiphyses of the humerus, badly united fractures of the forearm, and osteoarthritis of the elbow-joint are instances.

Soft parts.—Along the outer border descend the brachio-radialis and radial extensors of the carpus, fleshy above, tendinous below. About 3·7 cm. (1½ in.) above the styloid process of the radius, a fleshy swelling directed obliquely downwards and forwards from behind, across this outer border of the forearm, denotes the extensors of the thumb crossing those of the carpus.

Along the inner border is the fleshy mass of the pronator teres and flexors, the ulna being covered by the flexor carpi ulnaris and flexor profundus. The tendon of the pronator is inserted into the radius a little below its centre—a point of importance in the treatment of fractures and in amputation. The flexor carpi ulnaris tendon can be felt just above the wrist making for the pisiform bone; and just external to it lies the **ulnar artery,** about to pass over the transverse carpal (anterior annular) ligament. The course of the artery is denoted by a line drawn from the front of the internal epicondyle to the outer edge of the pisiform bone. If it be drawn from the bifurcation of the brachial, this line must in its upper third be made strongly convex inwards, in order to mark the upper part of the artery, here thickly covered by muscles. In **ligature of the artery** in *the middle* of the forearm, the white line and sulcus between the flexor carpi ulnaris and sublimis must be identified. A small muscular branch will often lead down to the artery. The line of the **ulnar nerve** is one drawn from the interval between the internal epicondyle and the olecranon to the inner side of the ulnar artery just above the wrist. The nerve joins the artery at the junction of the upper and middle thirds of the forearm. The **median nerve** runs in a line drawn from the inner side of the brachial artery, in the elbow triangle,

to a point beneath, or just to the inner side of, the palmaris longus just above the wrist. The **radial artery** will be marked by a line drawn from the centre of the bend of the elbow (where the brachial artery divides opposite to the neck of the radius) to a point just internal to the radial styloid process descending along the inner edge of the brachio-radialis. The muscular interval is that between the brachio-radialis and pronator teres above, and the flexor carpi radialis below. The **superficial radial (radial) nerve** will be marked by the same line (it lies just external to the artery) for its upper two-thirds; it then leaves the artery about 7·5 cm. (3 in.) above the wrist-joint, and passes to the back of the forearm under the tendon of the brachio-radialis. The **anterior interosseous artery** runs down on the interosseous membrane and passes to the back of the forearm by perforating it below, having passed behind the pronator quadratus. The **posterior interosseous**

FIG. 984.—DISTRIBUTION OF CUTANEOUS NERVES ON THE ANTERIOR AND POSTERIOR ASPECTS OF THE SUPERIOR EXTREMITY



lies between the superficial and deep extensors. These small arteries reinforce the palmar through the carpal arches, and thus bring down blood after ligature of the trunks above.

The front of the forearm is supplied by the musculo-cutaneous on the outer, and the medial antibrachial (internal) cutaneous on the inner, side; just above the wrist the palmar cutaneous branches of the median and ulnar perforate the deep fascia (fig. 984). The back of the forearm is supplied by the radial (musculo-spiral) and posterior branches of the musculo-cutaneous externally, and the posterior branches of the medial antibrachial (internal) cutaneous internally (fig. 984).

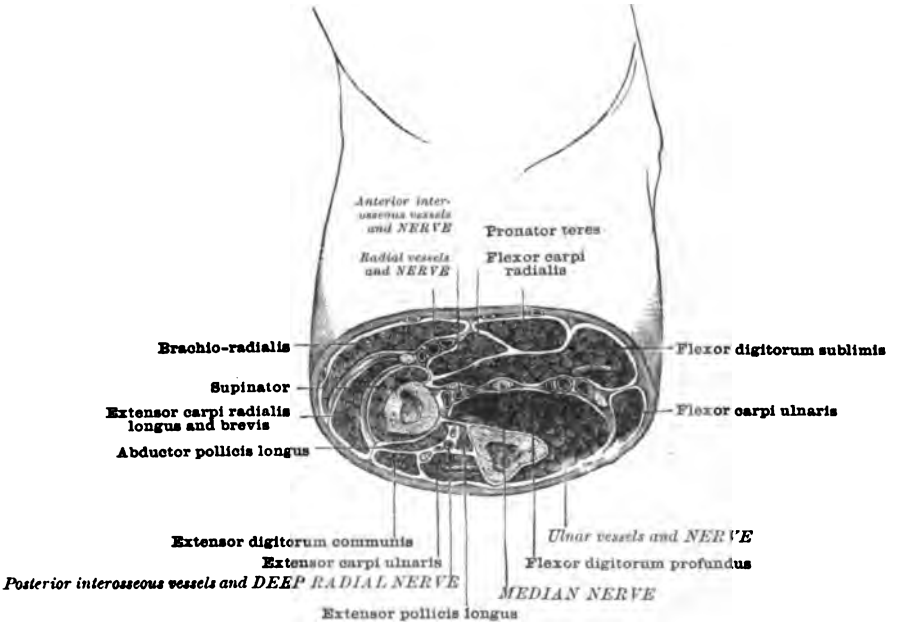
The **lymphatics of the upper extremity** are **superficial** and **deep**; the former run with the superficial veins, the latter with the deep vessels. As a rule, there are no **nodes** below the elbow. The lowest are the epitrochlear or Crookshank

nodes, lying with the basilic vein, a little above the inner epicondyle. The majority of the lymphatics open into the axillary nodes, and terminate, on the left side in the thoracic duct, on the right in the lymphatic duct. A few, accompanying the cephalic vein, reach the subclavian or infraclavicular nodes, and thus communicate with the lymphatics of the neck.

It will be well to briefly consider, here, the chief result of paralysis of the main nerves of the upper extremity.

Paralysis of the median nerve.—(*a*) *In forearm:* Loss of pronation. (*b*) *At wrist:* Diminished flexion and loss of radial adduction; the tendency now being towards ulnar adduction. (*c*) *In the hand:* Power of grasp is lessened especially in the thumb and outer two fingers. Owing to the loss of flexion in the phalanges of these fingers the phalanges are liable to become overextended by the action of the extensors and interossei. The thumb remains extended, adducted, and closely applied to the index, the human characteristic being thus lost, and the 'ape's hand' of Duchenne being produced. **Sensation** will be lost over the palmar aspect of the thumb and outer two and one-half fingers and over the distal ends of the same fingers, to a varying degree, according to the sensory distribution of the median and other

FIG. 985.—SECTION THROUGH THE MIDDLE OF THE RIGHT FOREARM. (Heath.)



cutaneous nerves. The above applies to lesions of the trunk. If the nerve be injured at the wrist, flexion of the wrist and fingers is less interfered with.

Paralysis of the ulnar nerve.—(*a*) *At wrist:* Power of flexion is diminished and that of ulnar adduction lost. (*b*) *In the hand:* Power of grasp will be lessened in the ring and little fingers. The interossei will be powerless to spread the fingers laterally, and there will be marked wasting of the first dorsal one. The same is the case with the hypothenar eminence. The thumb cannot be adducted, and power of flexion will be diminished. After a time, from the loss of balance between the flexors and extensors, the hand becomes 'clawed'—the first phalanges overextended, and the second and third flexed (**main en griffe**). Sensation will be lessened over the area supplied by the nerve.

Paralysis of the radial (musculo-spiral) nerve.—(*a*) *In the forearm:* This is flexed, extension being impossible. The forearm is pronated, supination being impossible save by the biceps, which acts now most strongly on a flexed elbow-joint. (*b*) *In the wrist:* This is dropped, owing to the loss of extension. (*c*) *In the hand:* The thumb is flexed and adducted. Some slight power of extension of the second and third phalanges of the fingers remains by means of the lumbricales and inter-

ossei. **Sensation** is impaired over the posterior and outer aspect of the forearm and lost to a varying extent over the distribution of the radial on the back of the hand.

Paralysis of the deep radial (posterior interosseous) nerve.—The evidence here is somewhat similar to that just given, but with the following differences. (*a*) *In the forearm:* There is no loss of extension, and the loss of supination is less as the brachio-radialis is not paralysed. (*b*) *At the wrist:* The 'drop' and loss of extension are not so marked, as the extensor carpi radialis escapes. **Sensation:** There is no loss.

Paralysis of the musculo-cutaneous nerve.—*Forearm:* Power of flexion is impaired, owing to complete paralysis of the biceps and partial of the brachialis anterior. **Sensation:** This is impaired over the outer aspect of the forearm, both back and front.

Amputation of forearm.—The 'mixed' method by skin-flaps roundly arched and circular division of the soft parts, the dorsal flap being the longer, is the most generally applicable. The bones should always be sawn below the pronator teres, when possible. In sawing them they must be kept parallel, the limb being in the supinated position. As the radius is the less securely held above, it is well to complete the section of this bone first. The relative position of the vessels has been indicated above (pp. 1350 and 1351, and fig. 985).

THE WRIST AND HAND

Bony points.—On the inner side the styloid process and, further outwards, the head of the ulna can be made out. On the outer side, the radial styloid process descends about 12 mm. ($\frac{1}{2}$ in.) lower than that of the radius, and is somewhat anterior to it. Abduction of the hand is thus less free than adduction. Between the apex of the styloid process and the ball of the thumb a bony ridge can be felt, with some difficulty, formed by the tubercle of the navicular and the ridge of the greater multangular (trapezium). At the base of the hypothenar eminence the pisiform can be more readily distinguished. The hook of the hamatum (unciform) lies below and to the radial side of the pisiform. On the front of the metacarpo-phalangeal joint of the thumb, the sesamoid bones can be distinguished.

At the back of the wrist and hand the triquetrum (cuneiform) bone can be felt below the head of the ulna; and more towards the middle line the prominence of the capitulum (os magnum), which supports the third or longest digit, and is the bone of the carpus most exposed to injury. A line drawn from the base of the fifth metacarpal bone to the radio-carpal joint, slightly curved downwards, will give the line of the carpo-metacarpal joints. (Windle.)

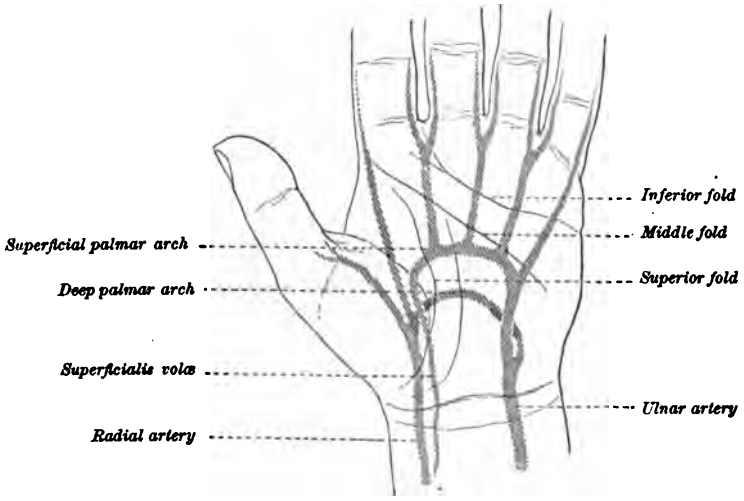
When the fingers are flexed, it will be seen that in each case it is the proximal bone which forms the prominence; thus, the knuckle is formed by the head of the metacarpal, the interphalangeal prominence by the head of the first phalanx, and the distal one by the head of the second. Thus, the joint in each case lies below the prominence, the distal joint being 2 mm. ($\frac{1}{12}$ in.), the interphalangeal 4 mm. ($\frac{1}{6}$ in.), and the metacarpo-phalangeal 8 mm. ($\frac{1}{3}$ in.) below its prominence.

Skin and Skin-folds.—The *skin* over the palm is thickened over the heads of the metacarpal bones and hypothenar eminence, thinner over the thenar. It is peculiar in its absence of sebaceous glands and hair-follicles; hence the absence of boils and sebaceous cysts, unless implanted. It is intimately connected with the palmar fascia, hence the chief difficulty in operations when this is contracted. Over the pulp of the digits the skin is closely connected with the periosteum of each ungual phalanx. The importance of this is alluded to under the heading of whitlow (*vide infra*). **Skin-folds:** two or three of these are seen on the palmar surface of the wrist: two lower down, and usually close together, and one less well marked, a little higher up upon the forearm. None of these corresponds exactly to the wrist-joint (p. 1347). The lowest 'precisely crosses the arch of the os magnum in the line of the third metacarpal bone' (Tillaux), and is not quite 18 mm. ($\frac{3}{4}$ in.) below the arch of the wrist-joint. It is about 12 mm. ($\frac{1}{2}$ in.) above the carpo-metacarpal joint line, and indicates very fairly the upper border of the transverse carpal (anterior annular) ligament.

'Of the many creases in the skin of the palm, three require especial notice. The first starts at the wrist, between the thenar and hypothenar eminences, and, marking

off the former eminence from the palm, ends at the outer border of the hand and at the base of the index-finger. The second fold is slightly marked. It starts from the outer border of the hand, where the first fold ends. It runs obliquely inwards across the palm, with a marked inclination towards the wrist, and ends at the outer limit of the hypothenar eminence. The third, lowest, and best marked of the folds starts from the little elevation opposite the cleft between the index- and middle fingers, and runs nearly transversely to the ulnar border of the hand, crossing the hypothenar eminence at the upper end of its lower fourth. The first fold is produced by the adduction of the thumb; the second, mainly by the bending simultaneously of the metacarpo-phalangeal joints of the first and second fingers; and the third by the flexion of the three inner fingers. The second fold, as it crosses the third metacarpal bone, about corresponds to the lowest part of the superficial palmar arch. The third fold crosses the necks of the metacarpal bones, and indicates pretty nearly the upper limits of the synovial sheaths for the flexor tendons of the three outer fingers. A little way below this fold, the palmar aponeurosis breaks up into its four slips, and midway between the fold and the webs of the fingers lie the metacarpo-phalangeal joints. Of the transverse folds across the fronts of the fingers, corresponding to the metacarpo-phalangeal and interphalangeal joints, the highest is placed nearly 18 mm. ($\frac{3}{4}$ in.) below its corresponding joint. The middle folds are multiple for all the fingers, and are exactly opposite to the first interphalangeal

FIG. 986.—RELATION OF THE PALMAR ARCHES TO THE FOLDS OF THE PALM. (Modified from Tillaux.)

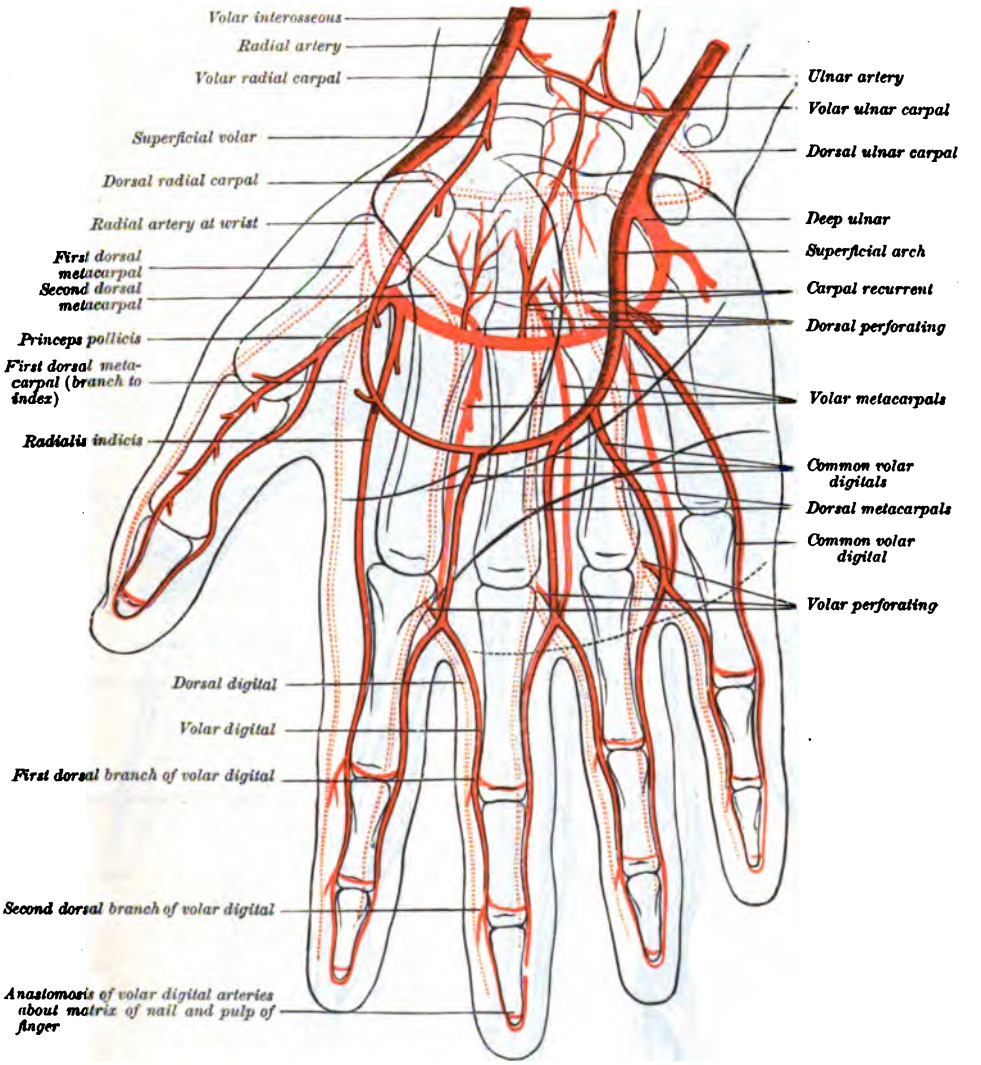


joints. The lowest creases are single, and are placed a little above the corresponding joints. There are two single creases on the thumb corresponding to the two joints, the higher crossing the metacarpo-phalangeal joint obliquely. The free edge of the web of the fingers, measured from the palmar surface, is about 18 mm. ($\frac{3}{4}$ in.) from the metacarpo-phalangeal joints. (Treves.)

The **superficial volar arch,** formed by the ulnar anastomosing with the superficial volar, or radialis indicis, will be shown by a line descending to the radial side of the pisiform bone, and then, a little lower, curving across the palm on a line with the thumb when outstretched at right angles with the index-finger. The four common digital arteries, the main branches of the superficial arch, run downwards along the interosseous spaces, and bifurcate 12 mm. ($\frac{1}{2}$ in.) above the webs of the fingers; the innermost digital does not bifurcate. The digital arteries then descend along the sides of the fingers under the digital nerves, giving off twigs to the sheath of the tendons, which enter by apertures in it, and run in the vincula vasculosa. It is owing to the readiness with which these tiny twigs are strangled by inflammation that sloughing of the tendon takes place so readily and irreparably. Throughout its course the superficial volar arch deserves its name. It is only covered by the palmaris brevis and central part of the palmar fascia. Beneath it, from within out-

wards, are the flexor brevis and opponens digiti quinti, the digital branches of the ulnar and median nerves, and the flexor tendons and lumbricales. The **deep volar arch,** formed by the radial and communicating branch of the ulnar, lies about 12 mm. (½ in.) nearer to the wrist than the superficial. It is not so curved as the superficial arch, and rests upon the interossei and metacarpal bones just below their bases. The structures separating it from the superficial arch have been already given. Owing to the frequency of wounds here, the relation of *the structures in front of the wrist* is most important. The radial artery lies between the tendon of the brachio-radialis and flexor carpi radialis. Next to this tendon is the palmaris longus, when present.

FIG. 987.—ANASTOMOSES AND DISTRIBUTION OF THE ARTERIES OF THE HAND.

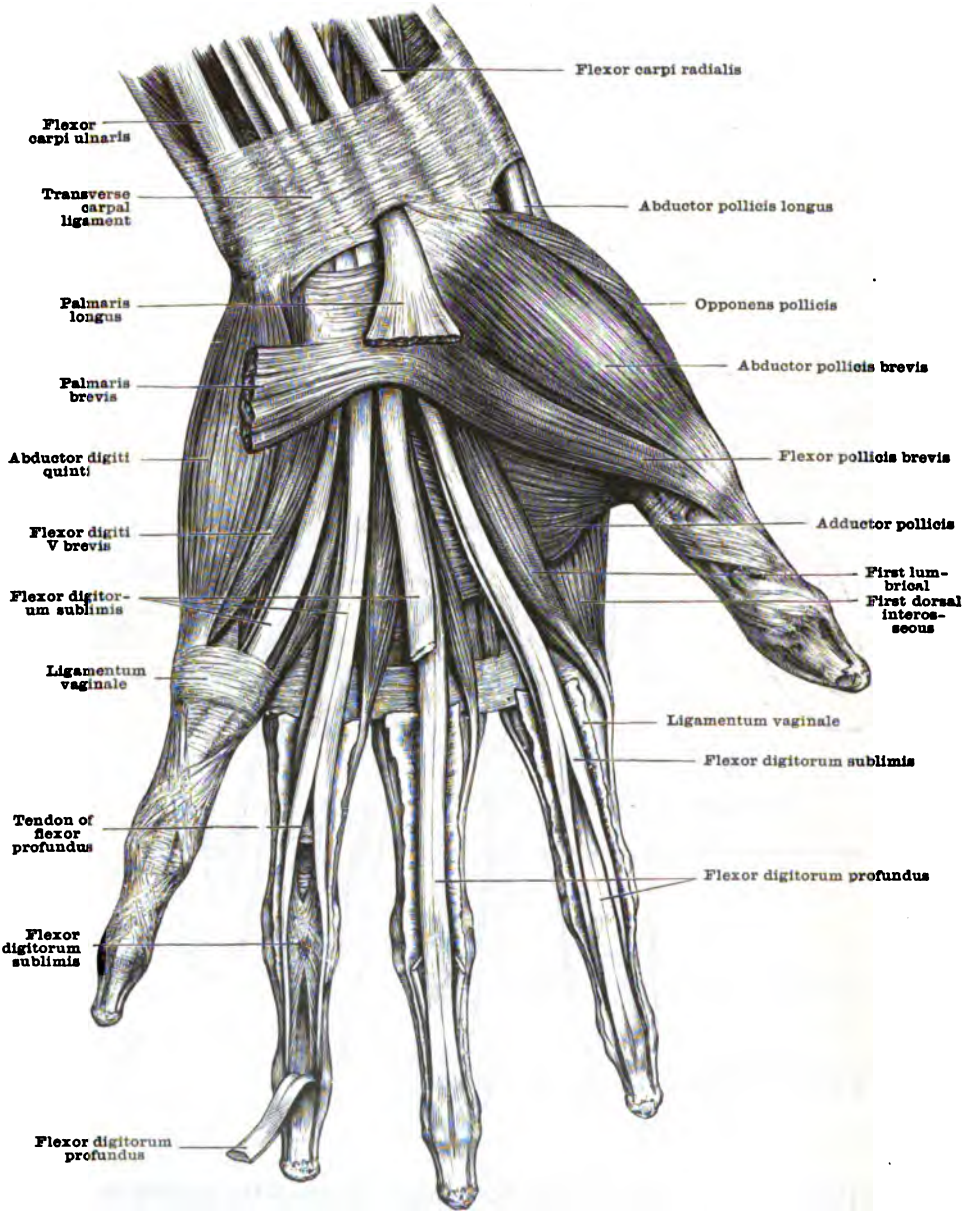


Between the last two tendons or under the palmaris longus is the median nerve. To the inner side of the palmaris longus is the flexor sublimis, the tendons for the middle and ring-finger being in front. The tendon of the flexor carpi ulnaris is most internal, and between this and the superficial flexor of the finger the ulnar nerve and vessels have come up into a superficial position.

Fasciæ and sheaths.—The **transverse** and **dorsal carpal (annular) ligaments** bind down and hold in place the numerous tendons about the wrist. The **transverse carpal (anterior annular),** when healthy, cannot be detected. It is attached to the pisiform and triquetral (cuneiform) bones on the inner, and to the navicular and greater

multangular (trapezium) on the outer, side. The ulnar nerve and vessels, the superficial volar, and palmar cutaneous branches of the median and ulnar pass over it. The ulnar artery and nerve are especially protected by their position between the pisiform and hook of the hamate (unciform), and also by a process of the flexor carpi ulnaris, which passes to the transverse ligament, thus forming a kind

FIG. 988.—THE SUPERFICIAL MUSCLES OF THE PALM OF THE HAND.

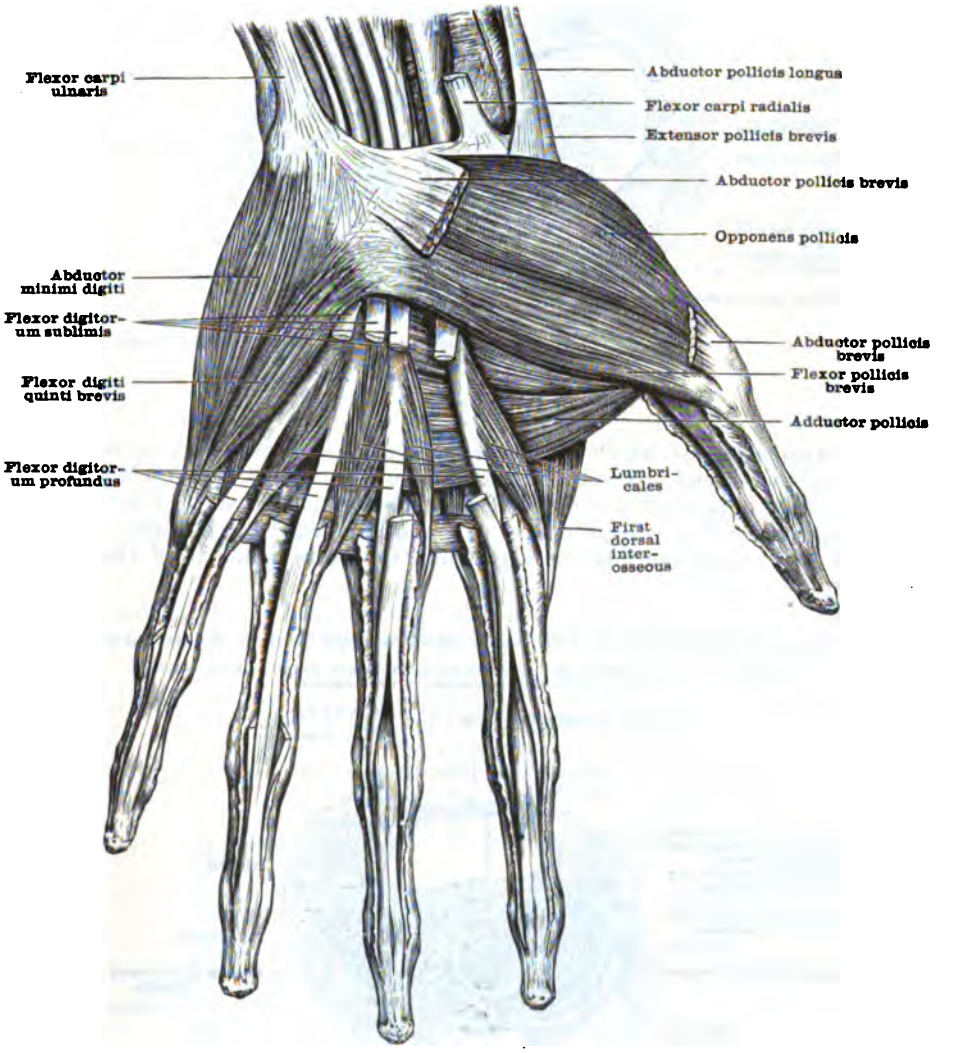


of tunnel. The flexor carpi radialis passes through a separate sheath formed by the ligaments and the groove in the greater multangular (trapezium); while beneath the ligaments lie the flexor tendons, the median nerve, and accompanying artery. Attached to its upper border is the deep fascia of the forearm, and to its lower the palmar fascia and the palmaris longus tendon, while from the outer and inner parts arise some of the thenar and hypothenar muscles. The upper border of the trans-

verse carpal (anterior annular) ligament corresponds to the lower of the two lines which cross the wrist just above the thenar and hypothenar eminences. The large synovial sheath, for all the flexors of the fingers, reaches beneath and below the transverse ligaments as far as the middle of the palm, and above the wrist for 37 to 50 mm. (1½ to 2 in.).

The **dorsal carpal (posterior annular) ligament** is attached to the back of the outer margin of the radius above the styloid process, and internally to the back of the triquetrum (cuneiform) and pisiform. Its direction is oblique, being higher on the radial side. It contains six tendon-compartments, of which four are on the radius.

FIG. 989.—THE DEEPER MUSCLES OF THE PALM OF THE HAND.

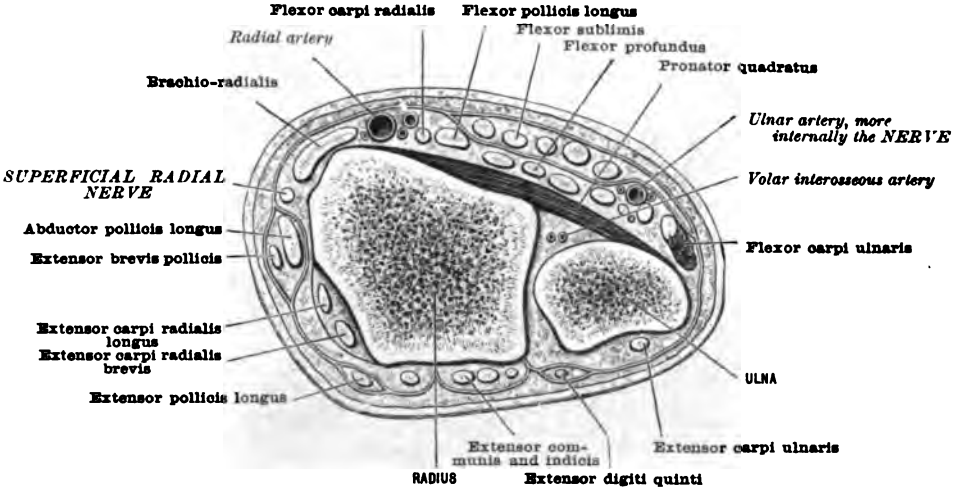


The outermost contains the long abductor and short extensor of the thumb; the second the two radial extensors of the carpus; the third, the extensor pollicis longus; this deep and narrow groove can be identified when the hand is extended, by its prominent outer margin; the fourth transmits the extensor communis and extensor indicis proprius; the fifth, lying between the radius and ulna, the extensor digiti quinti; and the sixth, lying just outside the styloid process of the ulna, the extensor carpi ulnaris. The sheaths for the last two extensors are the only ones which follow the tendons of their insertion, the others ending at a varying distance below the

carpal (annular) ligament. The lower border of the dorsal carpal (posterior annular) corresponds to the upper margin of the transverse carpal (anterior annular) ligament.

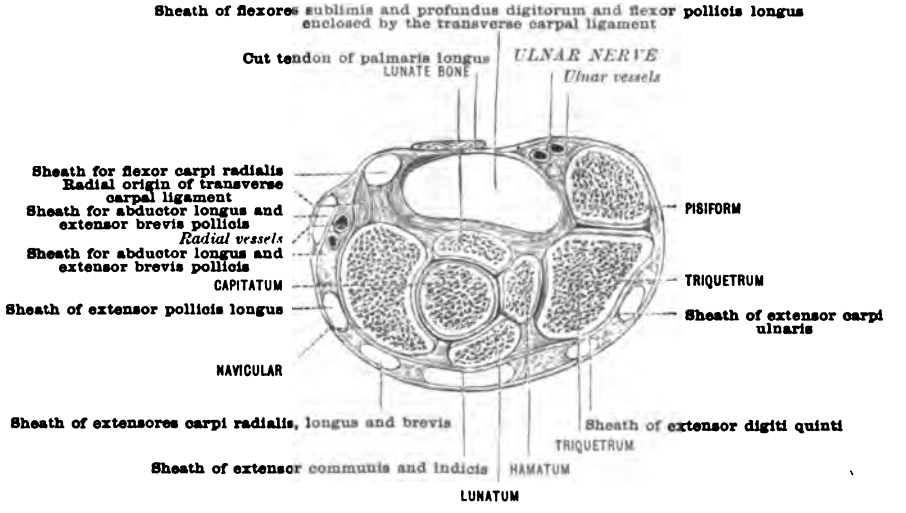
The **palmar aponeurosis,** by its strength, toughness, numerous attachments, and intimate connection with the superficial fascia and skin is well adapted to protect the parts beneath from pressure. The thenar and hypothenar muscles are

FIG. 990.—SECTION THROUGH REGION OF WRIST, A LITTLE ABOVE THE JOINT. RIGHT SIDE, UPPER HALF OF THE SECTION. (Tillaux.)



enclosed in two processes, which are thinner so as not to interfere with the contraction of the subjacent muscles. The central part, pointed above at its attachment to the carpal (annular) ligament, spreads out fan-like below, and gives off four slips, each of which bifurcates into two processes, which are attached to the sides of the first phalanx of each finger and into the superficial transverse ligament of the web and

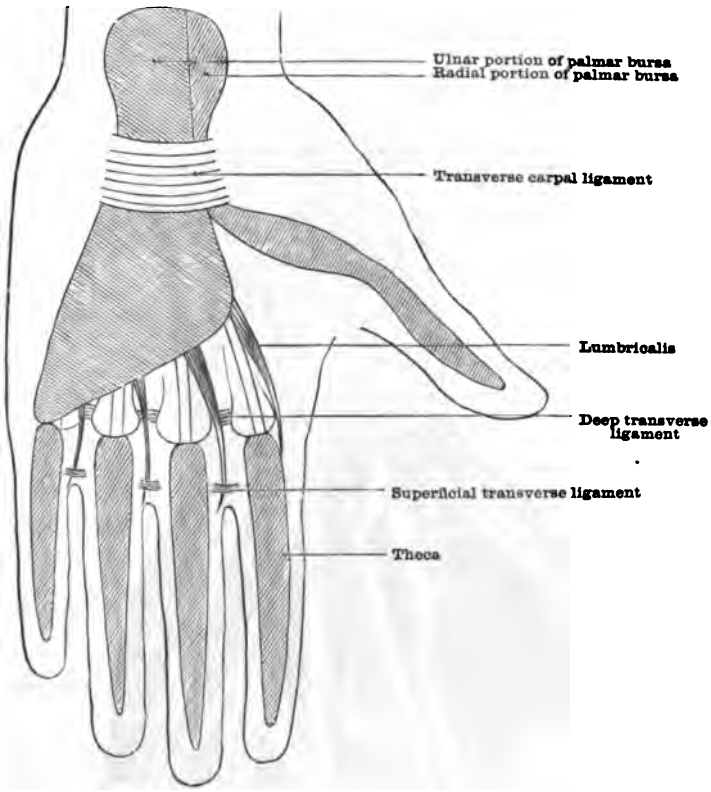
FIG. 991.—TRANSVERSE SECTION OF THE WRIST THROUGH THE MIDDLE OF THE PISIFORM BONE.


Sheath of flexores sublimis and profundus digitorum and flexor pollicis longus enclosed by the transverse carpal ligament
Cut tendon of palmaris longus
LUNATE BONE
ULNAR NERVE
Ulnar vessels
Sheath for flexor carpi radialis
Radial origin of transverse carpal ligament
Sheath for abductor longus and extensor brevis pollicis
Radial vessels
Sheath for abductor longus and extensor brevis pollicis
PISIFORM
CAPITATUM
TRIQUETRUM
Sheath of extensor pollicis longus
Sheath of extensor carpi ulnaris
NAVICULAR
Sheath of extensores carpi radialis, longus and brevis
Sheath of extensor digiti quinti
TRIQUETRUM
Sheath of extensor communis and indicis
HAMATUM
LUNATUM

the deeper one which ties the heads of the metacarpal bones together. Transverse fibres pass between the processes into which each of the four slips bifurcates, and thus form the beginning of the theca, which is continued down the finger to the base of the last phalanx. It is the contraction of the palmar aponeurosis, especially of the

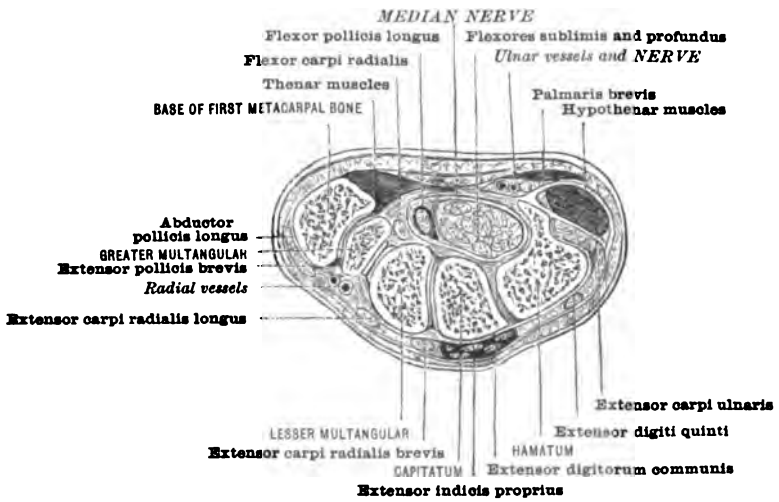
slip to the two inner fingers, which gives rise to Dupuytren's contraction. The **theca** is strong opposite the first two phalanges (ligamentum vaginale), weak and

FIG. 992.—DIAGRAM OF THE GREAT PALMAR BURSA.



loose opposite the joints (ligamentum annulare). The density of this osseo-fibrous tunnel and its close proximity to the digital nerves explain the pain in thecal in-

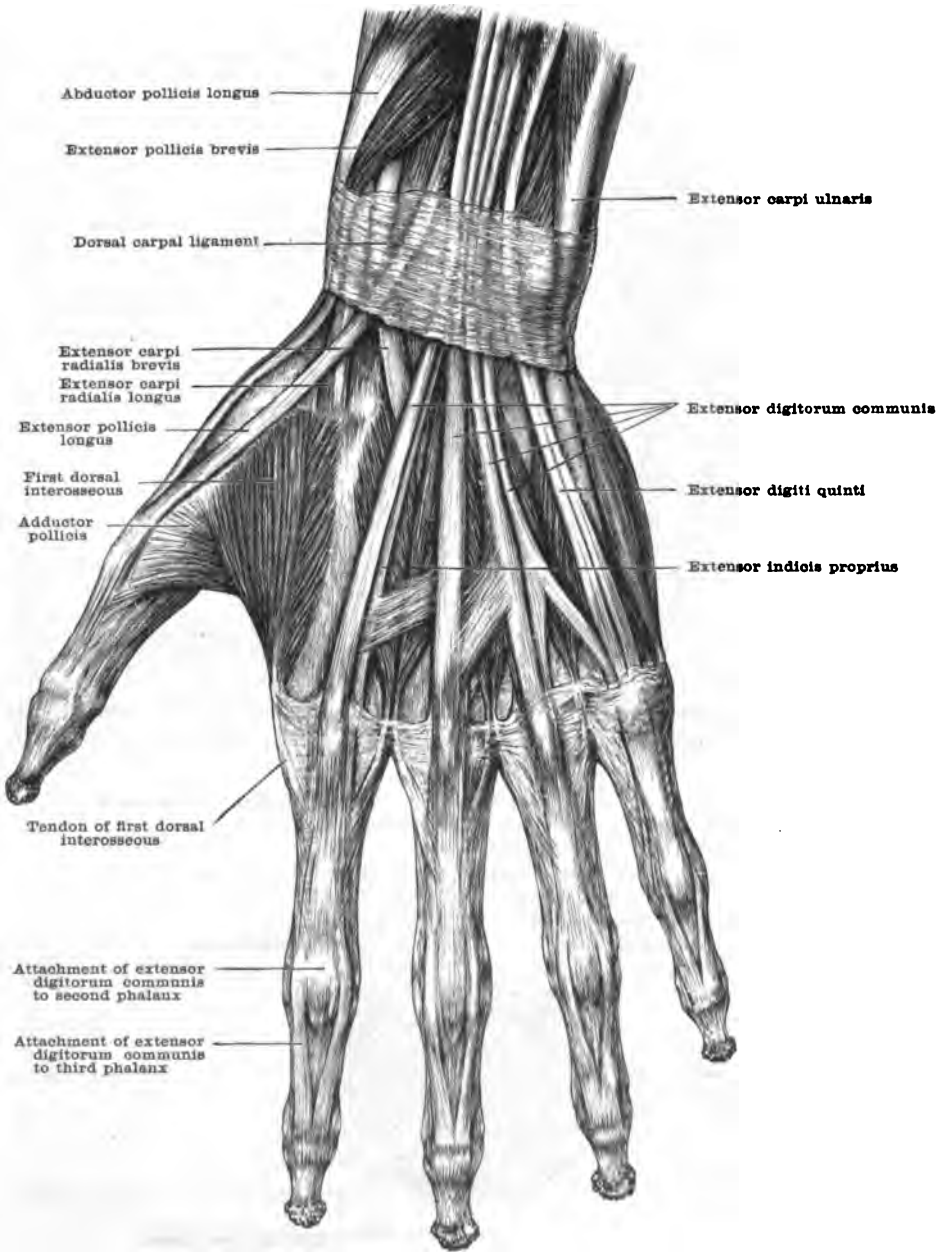
FIG. 993.—SECTION OF CARPUS THROUGH THE UNCIFORM BONE. (Two-thirds.)
(Bellamy, after Henle.)



flammation. Its tendency to gape widely after section is to be remembered in amputations through infected parts.

Synovial membranes.—Beneath the transverse carpal (anterior annular) ligament lie two **synovial sacs,** one for the flexor pollicis longus, and one for the superficial and deep flexors of the fingers. They extend above the transverse (annular) ligament for rather more than 2·5 cm. (1 in.). The two sacs may communicate. A compound palmar ganglion has an hour-glass outline, the transverse carpal (annular) ligament forming the constriction.

FIG. 994.—TENDONS UPON THE DORSUM OF THE HAND.

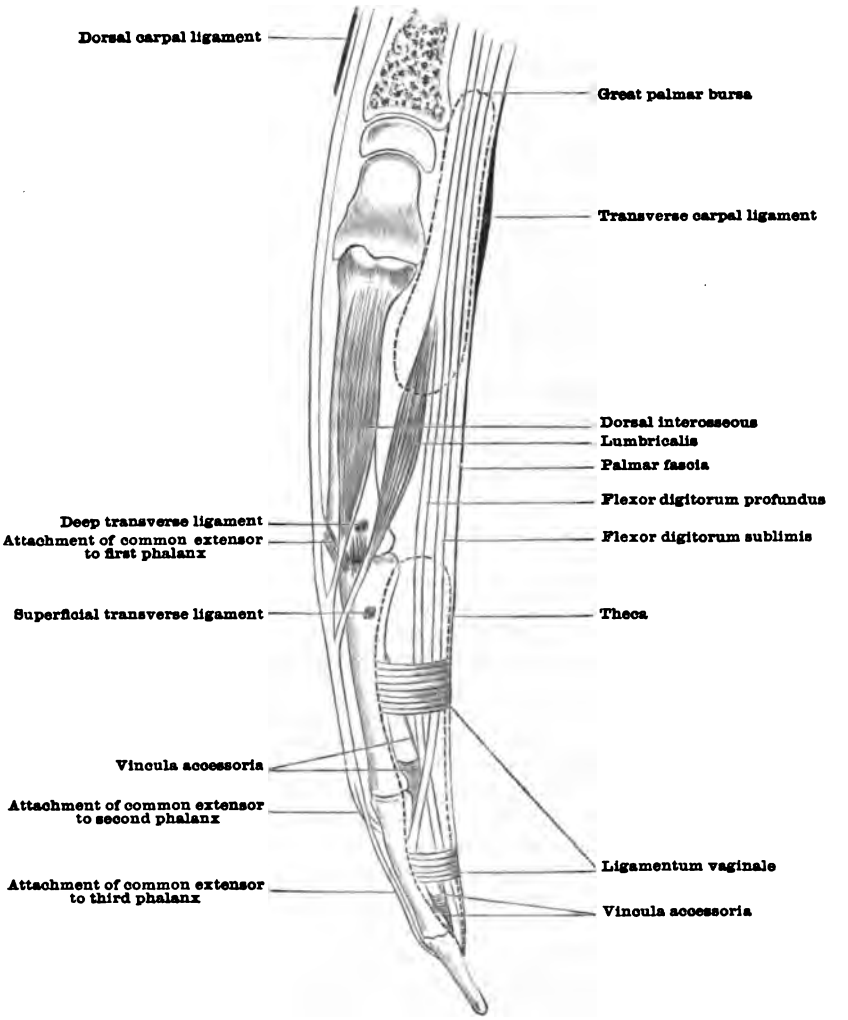


The creaking sensation in teno-synovitis and that of 'melon-seed' bodies often present in tuberculosis here is well known. The sheath for the long flexor of the thumb reaches to the base of the last phalanx. That for the finger-flexors gives off four processes. The one for the little finger also reaches to the base of the last phalanx. Those for the index-, middle, and third fingers end about the middle of

the metacarpal bones. Traced from the insertions of the flexor profundus, the digital synovial sheaths extend upwards into the palm as far as the bifurcation of the palmar fascia (p. 1358), i. e., into a point about opposite to the necks of the metacarpal bones, denoted on the surface by the crease which corresponds to the flexion of the fingers. Thus, about 12 mm. ($\frac{1}{2}$ in.) separates the sheaths of the outer three fingers from the large synovial sac beneath the transverse carpal (annular) ligament. There is no synovial sheath beneath the pulp of the fingers or thumb, this part lying on the periosteum of the last phalanx.

This has an important bearing on **whitlow**. Infection here may be merely *subcuticular*, or deeper, in the latter case from the connection of the skin with the periosteum here existing

FIG. 995.—DIAGRAM OF A VERTICAL SECTION THROUGH THE MIDDLE OF THE HAND.



the bone is soon affected, and necrosis keeps up a tedious ulcer. As the two centres of the phalanx do not unite till about the twentieth year, the distal one only requires removal; as the flexor sheath only reaches to the insertion of the flexor, i. e., into the proximal, part of the bone, both sheath and tendon may escape implication. Higher up along the fingers whitlow may be *cellulo-cutaneous* or *thecal*. While the continuity of the synovial sheath in the little finger and thumb (p. 1360) renders infection here more dangerous, the short gap between the digital and the palmar sacs is readily traversed by acute infection, with all the grave results of thecal suppuration.

Incisions in the palm. Over the distal phalanges these should be made down to the bone in the lower two-thirds of the pulp. In thecal suppuration of the next two phalanges the sheath must be opened by incisions over the phalanges, the joints being avoided. In the palm itself incisions may be safely made—(*a*) below the superficial volar arch, over the lower part of the metacarpal bones; (*b*) above the arch, accurately between the thenar and hypothenar eminences,

the incision being deepened by Mr. Hilton's method. Above the transverse carpal (annular) ligament, if the above precaution be taken, the palmar bursa is reached by an incision a little to the inner side of the centre, the line of the median nerve (p. 1350) being remembered. If the upper part of the sheath of the flexor pollicis longus especially requires opening, an incision to the inner side of the radial artery will reach it.

Deeper down are the **articular synovial sacs,** five in number:—(1) Between the interarticular cartilage and the head of the ulna; (2) between the radius and the interarticular cartilage above, and the navicular and lunate and triquetrum (cuneiform) below; (3) between the greater multangular (trapezium) and first metacarpal bone; (4) between the pisiform and the triquetral (cuneiform) bone; (5) between the two rows of carpal bones, sending two processes upwards between the three bones of the upper row, and three downwards between the four of the lower row; these three processes being also continued below into the inner four carpo-metacarpal and three intermetacarpal joints.

Beneath the palmar aponeurosis covering the thenar eminence are the following structures:—Superficial volar artery, abductor pollicis brevis, opponens pollicis, radial head of short flexor, tendon of long flexor, ulnar head of short flexor, first volar metacarpal (princeps pollicis and radialis indicis) arteries, metacarpal bone of the thumb, with the tendon of the flexor carpi radialis and greater multangular (trapezium).

Beneath the central part of the palmar aponeurosis are the superficial arch and its digital branches; the ulnar and median nerves, with their branches; the flexors, superficial and deep, with their synovial sheath; and the lumbricales; then a layer of connective tissue (the only structure, together with the deep layer of fascia over the interossei, which prevents matter pent in by the palmar aponeurosis from making its way back out through the dorsum), the deep arch, the interossei, and the metacarpal bones.

In the hypothenar eminence under the fascia are part of the ulnar artery and nerve, the abductor and flexor brevis digiti quinti, the opponens, the deep branch of the ulnar artery and nerve, and the fifth metacarpal bone.

The back of the wrist and hand.—The dorsal carpal (posterior annular) ligament has already been described. On the outer side is the so-called 'snuff-box space' (*tabatière anatomique* of Cloquet), a triangular hollow, bounded towards the radius by the long abductor and short extensor of the thumb, and towards the ulna by the long extensor. The navicular and greater multangular (trapezium), with their dorsal ligaments, form the floor. In the roof lie the radial vein and branches of the radial nerve. More deeply is the artery, following a line from the apex of the styloid process to the back of the interosseous space. The different tendons have already been given. Between the first two metacarpal bones is the first dorsal interosseous muscle, which forms a fleshy projection against the radial side of the index metacarpal, when the thumb and index are pressed together. On its palmar aspect is the adductor pollicis. Wasting of the former muscle is a ready indication of injury or disease of the ulnar nerve.

The skin on the dorsum, by its laxity, readily allows of œdema, this being sometimes evidence of pressure on the axillary vein by carcinomatous deposits. The dorsal venous arch receives the digital plexuses, and from it the radial and posterior ulnar veins ascend. The median vein begins in plexuses at the root of the thumb and the front of the wrist.

Ganglia are common on the dorsum, in connection with the extensors of the fingers and the thumb. While usually due to a weakening of the sheath and protrusion of this and the synovial membrane, such swellings may be due to a projection of the articular synovial membrane. Owing to the laxity of the skin, the slight vascularity, the size of the tendons, their connection with joint-capsules and with each other, which fixes them, the dorsum of the wrist is the 'seat of election,' for **tendon-anastomosis** and other operations. **Metacarpo-phalangeal dislocation.** This occurs in the thumb and the index-finger especially. The chief cause in the difficulty in reduction is the glenoid ligament. This, in reality a fibro-cartilaginous plate, is blended with the lateral ligaments on the palmar aspect of the joint, and is firmly attached to the phalanx, but more loosely to the metacarpal. Thus when dislocation occurs in violent hyperextension, the metacarpal attachment of the glenoid ligament gives way and it is carried by the phalanx over the head of the metacarpal bone. In the case of the thumb, the buttonhole-like slit with which the two heads of the flexor brevis, now displaced, embrace the head of the metacarpal, the contraction of the other short muscles, and, occasionally, a displaced long flexor, are additional causes. In the case both of the thumb and finger, tilting the phalanx well back on the dorsum of the metacarpal, and then combined pressure with the thumbs forwards against the

base of the phalanx, when this is sharply flexed, will with an anæsthetic, be usually successful. The thumb should be, first, adducted into the palm.

Amputation of finger at the metacarpo-phalangeal joint.—This is best effected by two lateral incisions which start 6 mm. (¼ in.) above the head of the bone, diverge over the base of the phalanx, and meet again on the centre of the base of the palmar aspect of the first phalanx, well below the web. This method avoids the hitch, usually met with in the racket-shaped method, in carrying the knife around one finger, between two others. The chief points to pay attention to are the site of the joints, three-quarters of an inch above the web, and not to interfere with the palm. The head of the bone is only to be removed for the sake of appearance, as doing so weakens the grasp by interfering with the transverse ligament, and is liable to open up the palm. The gaping of the theca and the ready slipping up of the flexor tendons are to be remembered when the parts are infected.

THE LOWER EXTREMITY

THE THIGH

Bony landmarks.—Many of these, such as the anterior superior spine and crest of the ilium and the tubercle (spine) of the pubis, have already been mentioned. The measurement of the limbs is obtained by placing them parallel and carrying the measure to the tip of the corresponding internal malleolus. The pelvis must be horizontal and the limbs parallel. The share taken by the femur and tibia respectively is estimated by finding the transverse sulcus which marks their meeting-point.

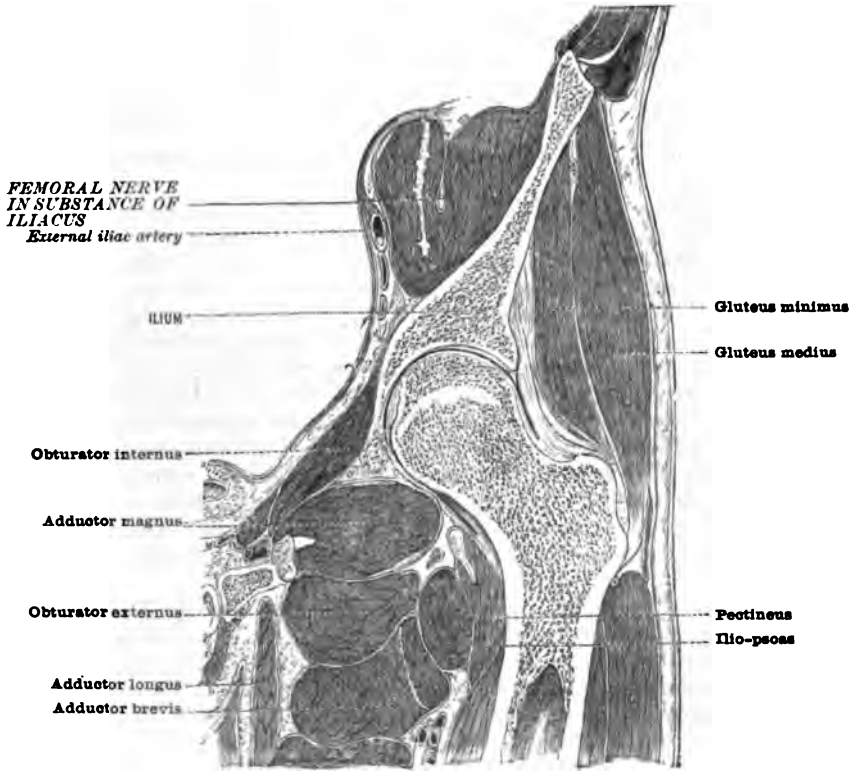
The head and shaft of the **femur** are well covered in, save in the emaciated. The head lies just below Poupart's ligament, under the ilio-psoas, and a little to the outer side of the centre of that ligament. A line drawn horizontally outwards from the pubic spine will cross the lower part of the head. All the head and the front of the neck, but only two-thirds of the back, are within the capsule; this intracapsular position of the upper epiphysis, which, appearing at the first year, does not unite till eighteen or twenty, accounts largely for the extreme gravity of acute epiphysitis here. The structure of the neck, i. e., the two sets of lamellæ, *vertical* to support the weight, *transverse* and *intersecting* in order to meet the pull of the muscles, and the wasting of these after middle life, has an important influence on injuries. The strong process, *femoral spur* or *calcar* (Merkel), which, arising from the compact tissue on the inner and under side of the neck, just above the lesser trochanter, spreads outwards towards the trochanteric (digital) fossa, also affords strength, and its degeneration probably plays an important part in the fractures of the neck.

Hip-joint.—The chief points of surgical importance are the following:—The capsule shows fibres chiefly longitudinal in front, circular behind. Of the former, the ilio-femoral or inverted Y-shaped ligament descends from the anterior inferior spine to the two extremities of the anterior intertrochanteric line. It not only checks extension and strengthens the front of the joint, but it keeps the pelvis and trunk propped forwards on the heads of the femurs, thus preventing waste of muscular action. It is joined on the inner side by the pubo-femoral ligament, which checks abduction. Between the two is the inner part of the front of the capsule, and here the ilio-psoas bursa may communicate with the joint. This fact must be remembered in tuberculous disease of the psoas, and the presence of this bursa explains certain deep-seated swellings in the front of the joint in adults. Behind, the ischio-femoral is the strongest part of the capsule, its fibres blending with the circular and weaker part of the capsule here. Dislocation usually occurs at the posterior, lower and inner part of the joint. It is to be noted that in full extension and flexion the head of the femur is in contact with the weakest spot in the capsule, in front and behind, respectively. From the deep aspect of the capsule fibres pass up at the line of reflection of the synovial membrane on to the neck—the cervical ligaments of Stanley. In intracapsular fracture these fibres keep the fragments together; hence one need of gentle handling; their softening may explain, a little later, an increase in the shortening. **Exploration of the joint.** This is usually effected by an oblique incision downwards and slightly inwards between the sartorius and rectus internally and the gluteus medius and minimus externally. A branch of

the ascending division of the external circumflex is the only artery met with. In tapping the joint the puncture is made in the same line, 2 or 3 inches below the anterior-superior spine. 'If the instrument is pushed upwards, inwards, and backwards beneath the rectus, it will pass into the joint a little above the anterior intertrochanteric line. (Stiles.)

Trochanter major.—This most valuable landmark is most prominent when the limb is rotated inwards or adducted; it lies at the bottom of a depression when the femur is everted. The chief structure of importance between it and the skin is the upper part of the insertion of the gluteus maximus, that going to the fascia lata, and the bursa beneath the muscle. This is often multilocular. It is, not very uncommonly, the seat of tubercular inflammation which readily invades the cancellous tissue of the trochanter. The top of the great trochanter is about 18 mm. ($\frac{3}{4}$ in.) below the level of the femoral head, and, when the femur is extended, is a little below the centre of the hip-joint. This part of the bone is covered by the

FIG. 996.—TRANSVERSE SECTION OF THE HIP-JOINT AND ITS RELATIONS. (One-third.) (Braune.)



gluteus medius. The slightness of the prominence of the great trochanter in the living subject compared with that in the skeleton is explained by fig. 996, which shows how the descending gluteus medius and minimus fill up the space between the ilium and trochanter. To examine the great trochanter, the thigh should be abducted, so as to relax the strong fascia lata passing upwards over the tensor and glutei to the iliac crest.

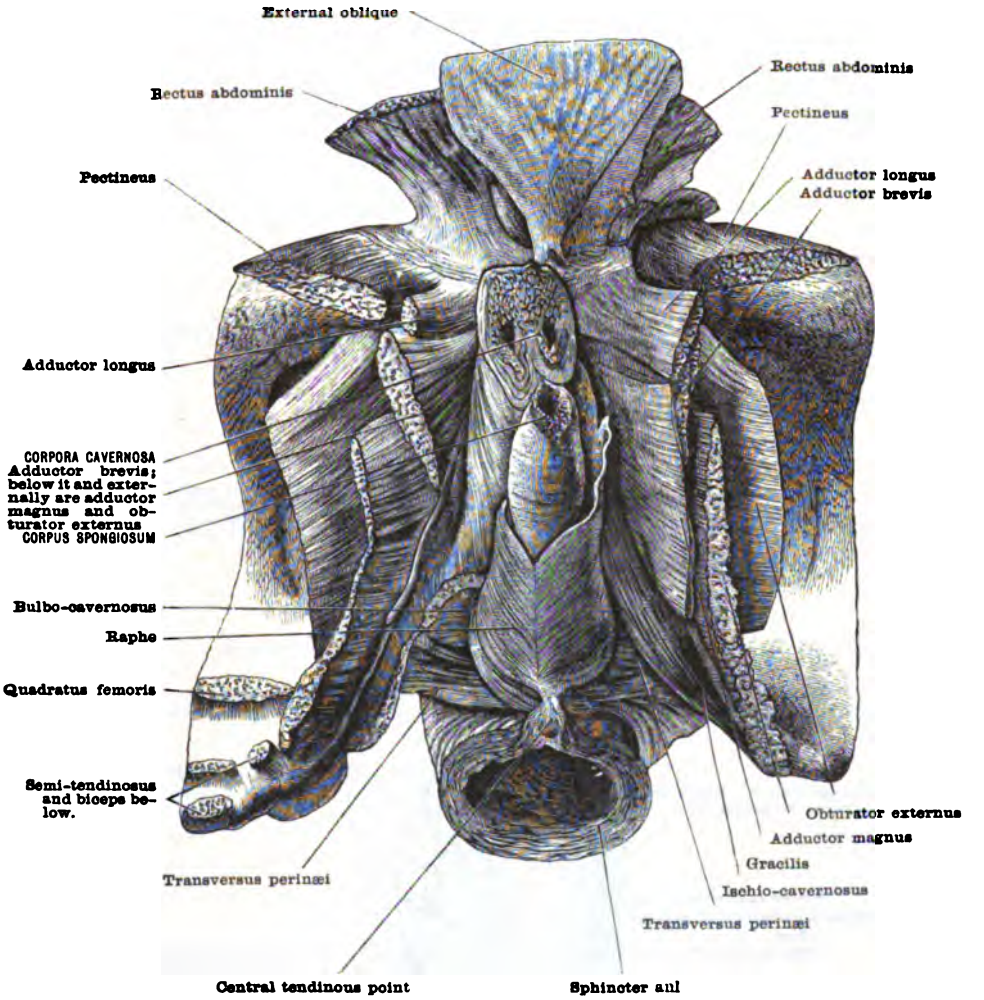
Nélaton's line.—This most useful guide is a line drawn from the anterior superior spine of the ilium to the most prominent part of the tuberosity of the ischium. In normal limbs, the top of the great trochanter just touches this line. In dislocation, fractures of the neck, and in wasting of the neck, as in osteo-arthritis, the relation of the trochanter to Nélaton's line becomes altered.

The top of the great trochanter is a guide in Mr. Adams's operation for division of the neck of an ankylosed femur, the puncture being made and the saw entered 25 mm. (1 in.) above and about the same distance in front of this point. Owing

to the fact that in many cases of ankylosis the neck is destroyed, the above operation has been largely replaced by the simpler and more widely applicable Gant's osteotomy just below the great trochanter, from the outer side.

Bryant's triangle.—Mr. Bryant makes use of the following in deciding the position of the great trochanter. The patient being flat on his back, (1) a line is dropped vertically on to the couch from the anterior superior spine; (2) from the top of the great trochanter a straight line in the long axis of the thigh is drawn to meet the first; (3) to complete the triangle, a line is drawn from the anterior superior spine to the top of the trochanter. This line is practically Nélaton's. The second line will be found diminished on the damaged or diseased side.

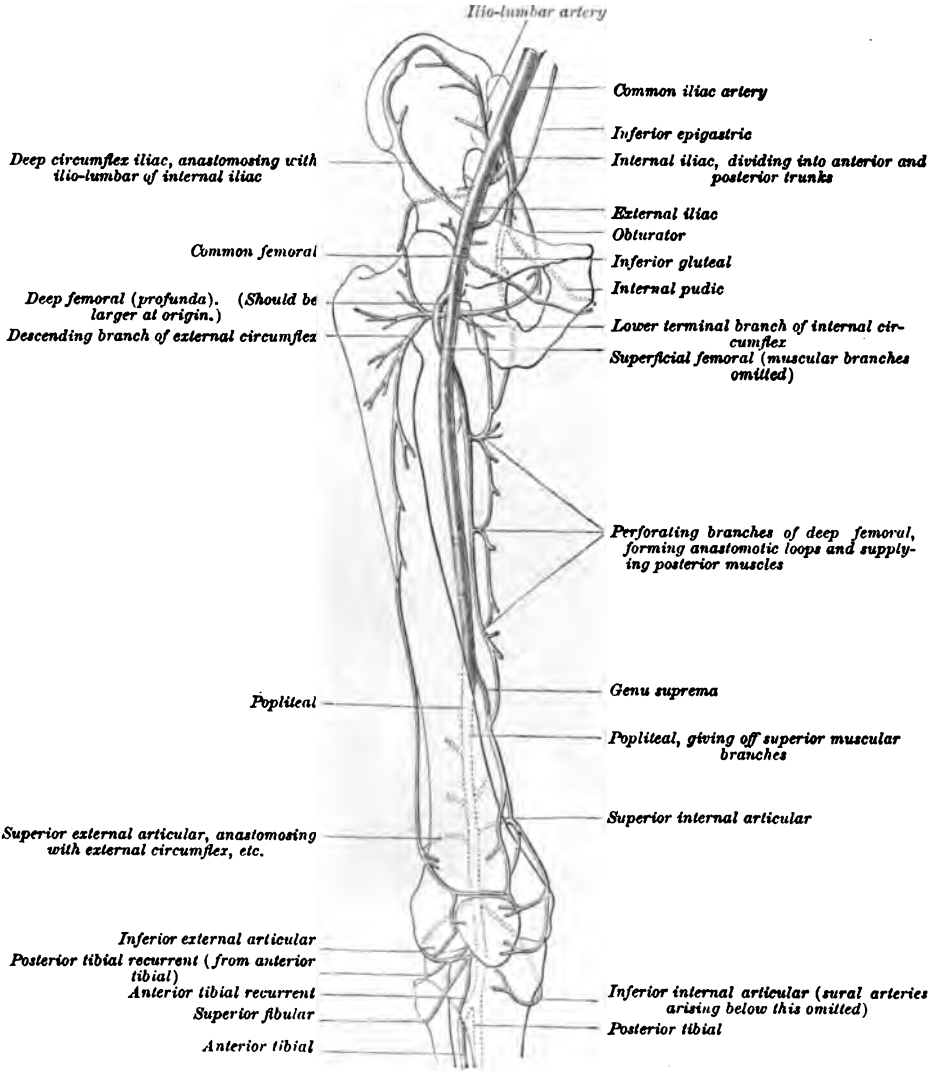
FIG. 997.—THE MUSCLES ATTACHED TO THE PUBES.
(From a dissection in the Hunterian Museum.)



Muscular prominences.—The tensor fasciæ latæ forms a prominence beginning just outside the sartorius and reaching downwards and somewhat backwards to the strong fascia lata, 75 to 100 mm. (3 to 4 in.) below the great trochanter. Below this point, as far as the outer tuberosity of the tibia, the strong ilio-tibial band can be felt. Like the inverted Y-shaped ligament, this band is a powerful saving of muscular action in maintaining the erect position. At the insertion of the tensor fasciæ latæ it bifurcates into two layers, which enclose the muscle. The superficial is attached to the iliac crest and the sheath of the gluteus medius; the deep blends with the capsule and the reflected head of the rectus. This deeper layer is perforated by the ascending branch of the external circumflex. The ilio-tibial

band is a guide for reaching the femur (p. 1370). The sartorius, the chief landmark of the thigh, forming a boundary of the femoral trigone (Scarpa's triangle), the adductor (Hunter's) canal, and the popliteal space, can be readily brought into view by the patient's raising his limb slightly rotated outwards. In the middle line the rectus muscle stands out in bold relief, with its tendon of insertion and the patella, when the leg is extended. On either side of this muscle is a furrow, and on either side, again, of this furrow the vasti become prominent. Between the vastus internus and adductor muscles is a depression indicating the adductor canal. At the upper and inner third of the thigh, if the limb be abducted, the

FIG. 998.—DIAGRAM OF ARTERIES OF THIGH.


Ilio-lumbar artery
Common iliac artery
Inferior epigastric
Deep circumflex iliac, anastomosing with ilio-lumbar of internal iliac
Internal iliac, dividing into anterior and posterior trunks
External iliac
Obturator
Common femoral
Inferior gluteal
Internal pudic
Deep femoral (profunda). (Should be larger at origin.)
Lower terminal branch of internal circumflex
Descending branch of external circumflex
Superficial femoral (muscular branches omitted)
Perforating branches of deep femoral, forming anastomotic loops and supplying posterior muscles
Genu suprema
Popliteal
Popliteal, giving off superior muscular branches
Superior internal articular
Superior external articular, anastomosing with external circumflex, etc.
Inferior external articular
Posterior tibial recurrent (from anterior tibial)
Anterior tibial recurrent
Inferior internal articular (sural arteries arising below this omitted)
Superior fibular
Posterior tibial
Anterior tibial

upper part of the adductor longus comes into strong relief. On the inner side below, above the knee-joint, the vertical fibres of the adductor magnus end in a powerful tendon coming down to the adductor tubercle (fig. 1001). This replaces here the internal intermuscular septum, and the insertion of the tendon marks the level of the lower epiphysial line of the femur. At the outer and back part of the thigh the vastus lateralis is separated from the biceps by a groove which indicates the external intermuscular septum. Of these **septa,** prolongations inwards from the fascia lata to the linea aspera, **the outer one** lies between the vastus externus and the biceps. It reaches from the outer tuberosity of the

FIG. 999.—SECTION OF THE RIGHT THIGH AT THE APEX OF THE FEMORAL TRIGONE. (Heath.)

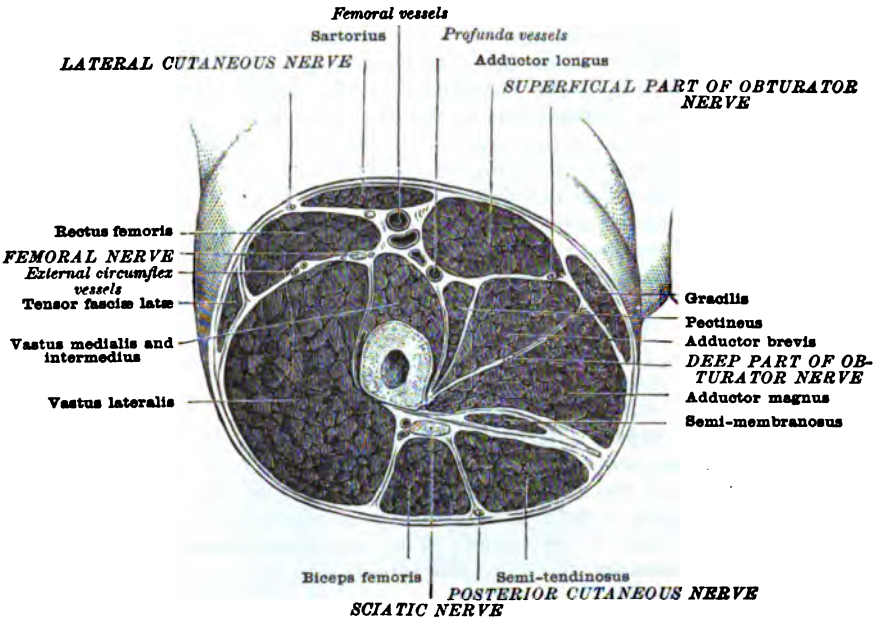
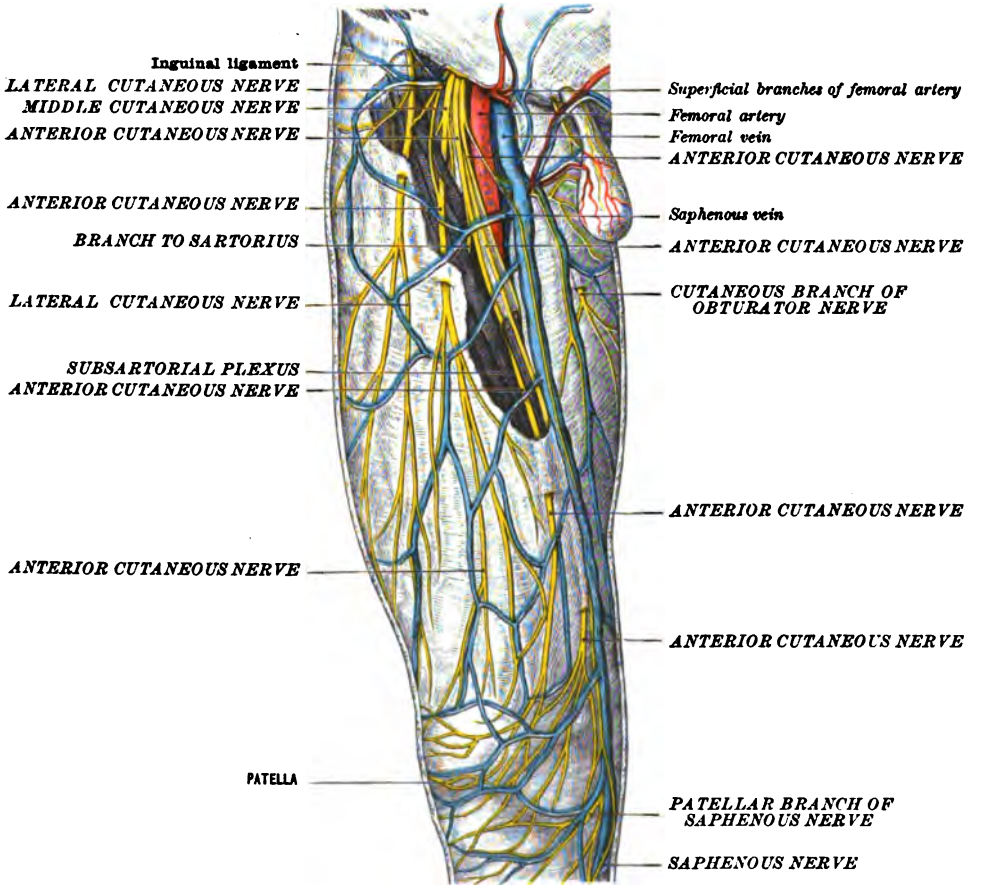


FIG. 1000.—SUPERFICIAL DISSECTION OF THE FRONT OF THE THIGH.
(Hirschfeld and Leveillé.)



femur to the insertion of the gluteus maximus. Just above the condyle it is perforated by the superior external articular vessel and nerve. The internal septum extends from the adductor tubercle to the trochanter. It is weak in comparison, and separates the adductor from the vastus internus. A **third**, the weakest of all, separates the adductor and the hamstrings. The **fascia lata** has the same effect as that in the neck in causing pus to burrow, especially downwards, and in rendering the diagnosis of swellings beneath it difficult. Thickest above and on the outer side, and again about the bony prominences at the knee-joint, at both of which sites it receives accessions from muscles, it is divided into **iliac** and **pubic portions.** The former attached behind to sacrum and coccyx, iliac crest and Poupart's ligament, ilio-pectineal line and pubic spine. Here it blends with the pubic portion, which is connected with the pubic arch. At the fossa ovalis (saphenous opening) the two may be said to separate, the iliac forming the upper cornu and outer falciform margin, and descending over the femoral vessels and extensors. The pubic, much thinner, forms the inner margin of the fossa, and descends obliquely over the pectineus and adductor longus behind the vessels, to blend with the sheath of the ilio-psoas and capsule of the hip-joint.

The **inguinal (Poupart's) ligament.**—The abdomen is separated from the thigh by a fold, best marked in flexion—the inguinal furrow. In this, pressure detects the meeting of the aponeurosis of the external oblique and the fascia lata, i. e., Poupart's ligament, extending between the anterior superior spine of the ilium and the tubercle (spine) of the pubes. The line representing it should be drawn slightly convex downwards, owing to the attachment of the deep fascia. It forms the base of the femoral trigone; its inner attachment blends with the triangular lacunar (Gimbernat's) ligament. The parts passing under Poupart's ligament and their arrangement have been given at p. 1326, fig. 966.

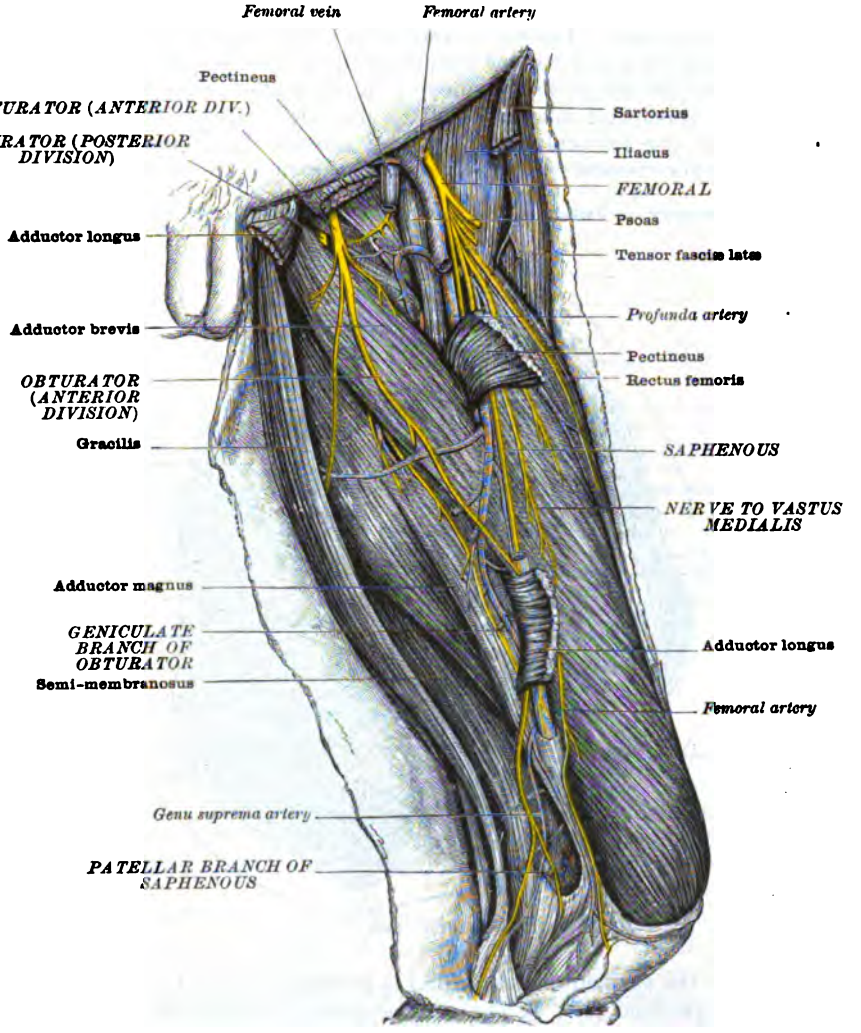
The **femoral trigone (Scarpa's triangle)** (fig. 1001).—Immediately below Poupart's ligament a hollow is seen corresponding to this region, the outer and inner boundaries of which are brought into view when the limb is raised, the adductor longus especially when the limb is abducted, and the sartorius when the thigh is flexed and the limb extended and rotated outwards. The floor of the femoral trigone is not horizontal, the plane of the inner part being very oblique. It is formed from without inwards by the ilio-psoas, pectineus, adductor brevis (slightly), and adductor longus. A **psoas abscess** descending below Poupart's ligament usually does so on the outer side of the femoral vessels; if the sheath gives way, or if the abscess follows the profunda artery, it will pass beneath the adductor longus and point towards the inner side of the thigh. (Taylor.) If it simulate a femoral hernia, examination of the back and the fact that the swelling is below the fossa ovalis (saphenous opening) will prevent mistakes. Three **nerves** come into the thigh between the pelvis and Poupart's ligament, i. e., the lumbo-inguinal (genito-crural) in the femoral sheath, the femoral (anterior crural) between the iliacus and psoas, and the lateral cutaneous close to the outer attachment of Poupart's ligament. The **obturator nerve** divides into two in the obturator foramen, the two divisions being separated by some fibres of the obturator externus, and lower down by the adductor brevis. The relations, course, and distribution of this nerve, in the inner fibres of the psoas, over the sacro-iliac joint and under the ilio-pelvic or sigmoid colon (Hilton), through the obturator foramen with its branches (from the superficial division) through the cotyloid notch to the hip, and (from the deep) along the popliteal artery to the knee, and others to the lower third of the thigh, and sometimes the upper and inner aspect of the leg (Hilton), may be of much surgical importance, e. g., in carcinoma of the bowel, disease of the sacro-iliac and hip-joints, growths of the pelvis, and the rare obturator hernia. The distribution of the cutaneous nerves is shown in fig. 1000. Lying superficially in the base of the trigone, the **inguinal lymphatic nodes** can be detected in a thin person (fig. 1013). They lie in two groups—(*a*) One horizontal in a line with Poupart's ligament, and receiving lymph from the genitals, the lower part of the abdominal wall, and the inner aspect of the buttock; (*b*) a vertical set lying along the great vessels receiving lymph from the limb.

The **fossa ovalis (saphenous opening).**—The depression corresponding to this is placed just below the lacunar (Gimbernat's) ligament, with which its upper extremity blends. Its centre is about 37 mm. (1½ in.) below and also external to a line dropped vertically from the pubic tubercle (spine). This and the other structures

concerned in femoral hernia are fully described under this section (*vide supra*, p. 1325). The course of the great saphenous vein is given below, p. 1286.

Line of femoral artery.—A line drawn from the mid-point between the anterior superior spine and the symphysis pubis to the adductor tubercle will correspond with the course of this vessel. The sartorius usually crosses it 100 mm. (3 to 4 in.) below Poupart's ligament. The profunda artery arises usually 37 to 50 mm. (1½ to 2 in.) below Poupart's ligament.

FIG. 1001.—FEMORAL AND OBTURATOR NERVES. (Ellis.)



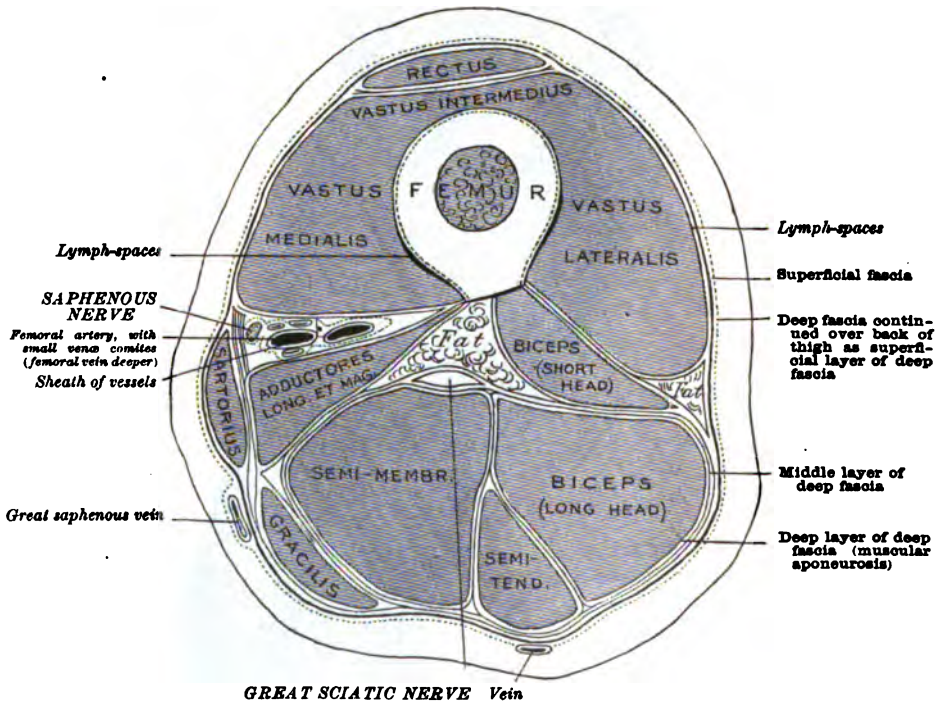
The incision for tying the femoral in the femoral trigone should be about 7·5 cm. (3 in.) long, in the line of the artery, and begins about 7·5 cm. (3 in.) below Poupart's ligament, and runs over the apex of the triangle. The femur is flexed slightly, abducted and rotated outwards. The fascia lata being divided, the sartorius, readily recognised by its direction, is drawn outwards. The closely subjacent sheath must be opened on its outer side. Structures that may be seen are a vein joining the great saphenous, the anterior cutaneous, saphenous nerve, and that to the vastus internus. The collateral *circulation* (fig. 997) is mainly through the following channels:—(1) The external and internal circumflex above, with the genu suprema (anastomotic) and lower muscular branches of the femoral; and the articular of the popliteal. (2) The perforating branches of the profunda above, with the vessels below first given. (3) The obturator artery above, with the internal circumflex below. (4) The deep circumflex above and the external circumflex below. (5) The comes nervi ischiadici with the articular of the popliteal.

The vein lies, below Poupart's ligament, immediately to the inner side of the artery. From this point on the vein gets to a somewhat deeper plane, though

still very close to the artery, and gradually inclining backwards, lies behind its companion at the apex of the triangle, and below lies somewhat to its outer side.

From the apex of the femoral trigone (Scarpa's triangle) a depression runs down along the inner aspect of the thigh, corresponding to the groove already mentioned (p. 1366) between the vastus medialis and the adductors. Along this groove lies the sartorius, and beneath it the **adductor (Hunter's) canal,** a triangular inter-muscular gap with its apex towards the linea aspera, and its base or roof formed by the fibrous expansion which ties together its boundaries, viz., the adductor longus and magnus and the vastus medialis. The vein, which in the upper part of the canal lies behind the artery, separating it from the three adductors, lower down inclines more and more to the outer side. The saphenous nerve lies also in the canal, but not in the sheath. The above-mentioned space terminates at about the junction of the middle and lower thirds of the thigh, in the opening in the adductor magnus by which the artery enters the upper and inner part of the popliteal space. The saphenous, the largest branch of the femoral nerve, having crossed the femoral vessels from without inwards, accompanies them as far as the opening in the adductor magnus.

FIG. 1002.—SECTION OF THIGH THROUGH UPPER PART OF HUNTER'S CANAL. (W. A.)



Here it perforates the aponeurotic roof, and is prolonged under the sartorius, accompanied by the superficial part of the genu suprema (anastomotic) artery, to perforate the fascia lata between the sartorius and gracilis, and run with the great saphenous vein at the upper and inner part of the leg.

Pressure may be applied to the femoral artery—(1) Immediately below Poupart's ligament: it should here be directed backwards so as to compress the vessel against the brim of the pelvis and the capsule of the hip-joint; (2) at the apex of the femoral trigone (Scarpa's triangle) the pressure here being directed outwards and a little backwards, so as to command the vessel against the bone; (3) in the adductor canal the pressure should be directed outwards with the same object. Care must be taken, especially above, to avoid the vein, which lies very close to the artery, and also the femoral (anterior crural) nerve, which enters the thigh about 12 mm. (½ in.) outside the artery, and at once breaks up into its branches, superficial and deep.

In **ligature of the femoral artery in Hunter's canal,** the line of the incision, in the middle third of the thigh, must exactly follow that of the vessel. It is frequently made too external, exposing the vastus medialis. Branches of the saphenous vein being removed, the fascia lata is slit up and the sartorius identified by its fibres descending inwards. Those of the vastus medialis are less oblique and are directed downwards and outwards. The sartorius having been drawn to the inner side, usually, the aponeurotic roof of the canal is opened, and the femoral sheath identified. The vein, here posterior and to the outer side, is closely connected to the artery.

The close contiguity of the femoral artery and vein accounts for the comparative frequency of arterio-venous aneurysms especially in the upper part, where the vessels are easily wounded. Their superficial position here further accounts for the facility with which malignant disease, e. g., epitheliomatous glands, may cause fatal hæmorrhage. **Access to the femur.** This is best attained on the outer side of the shaft along the line of the external intermuscular septum (p. 1366), the biceps being pulled backwards, and the vastus lateralis detached anteriorly. On the inner side the bone may be exposed by an incision starting from a point midway between the inner margin of the patella and the adductor tubercle and passing obliquely upwards and outwards, but the parts here are more vascular. The thickness of the periosteum in early life has an important bearing in infective osteoperiostitis, in the transverse 'green-stick' fractures, and, later, in syphilis. On the other hand, the thinness of the periosteum over the popliteal surface is a marked feature, hence the imperfect sheaths for any sequestra here. **Fractures** of the shaft usually occur about the centre. The main tendency to displacement is of the lower fragment upwards by the hamstrings, inwards by the adductors which also rotate it outwards. The upper fragment is anterior; this is especially marked in the upper third, owing to the action of the ilio-psoas, which also rotates the upper fragment outwards. In the lower third the forward curve of the femur and its more superficial position explain the fact that it is here that compound fractures of the femur may, occasionally, occur. **Ossification.** The unstable nature of the tissues about the upper epiphysis, which appears at the end of the first year and unites about eighteen, and the frequency of tuberculous disease in early life are well known. In the lower epiphysis ossification begins before birth, a point of medico-legal importance in deciding whether a newly born child has reached the full period of uterine gestation. From this epiphysis, the level of which is denoted by a line drawn horizontally outwards from the adductor tubercle, and the vascular growing tendon of the adductor magnus—*cf.* those about the attachment of the scalenus anterior and deltoid—the origin of an exostosis is not uncommon. **Displacement of this epiphysis** (it unites about twenty) in boyhood and adolescence is a grave injury from the immediate risk of the popliteal vessels. The mischief is usually done by overextension of the leg, as when this is caught in a rapidly moving carriage-wheel; the epiphysis is carried forwards in front of the diaphysis, the lower end of which is directed backwards, endangering the vessels which are posterior and closely adjacent.

Amputation through the thigh.—This is usually performed in the lower third, by anterior and posterior flaps, the former being the longer, so as to ensure a scar free from pressure, and circular division of the muscles, vessels, and nerves. The vessels requiring attention are the femoral, which lie at the inner side, and the more posteriorly, the lower the amputation; the descending branch of the external circumflex, and the termination of the profunda near the linea aspera. The femoral artery has a marked tendency to retract in the adductor canal. Care should be taken not to include the saphenous nerve when the femoral vessels are tied, and to cut the sciatic cleanly and high up. When amputation has to be performed in the upper third of the thigh, the tendency of the ilio-psoas to flex the shortened limb and thus bring the sawn femur against the end of the stump must be remembered, and met by keeping the patient propped up and the stump as horizontal as possible. Some of the structures now divided are shown in fig. 1002.

THE BUTTOCKS

Bony landmarks.—The finger readily traces the whole outline of the iliac crest. Behind, it terminates in the posterior superior spine, which corresponds in level to the second sacral spine and the centre of the sacro-iliac joint. (Holden.)

The third sacral spine marks the lowest limit of the spinal membranes and the cerebro-spinal fluid; it also corresponds to the upper border of the great sacro-sciatic notch.

The first piece of the coccyx corresponds to the spine of the ischium. (Windle.) Its apex is in the furrow just behind the last piece of the rectum.

The tuberosities of the ischium are readily felt by deep pressure on either side of the anus. In the erect position they are covered by the lower margin of the gluteus maximus. In sitting they are protected by tough skin, fasciæ, with coarse fibrous fat, and often by a bursa known, according to the patients in whom it becomes enlarged, as 'weaver's, coachman's, lighterman's, drayman's' bursa. The skin of the buttock is coarse and difficult to cleanse satisfactorily. The abundance of sebaceous glands accounts for the frequency of boils here.

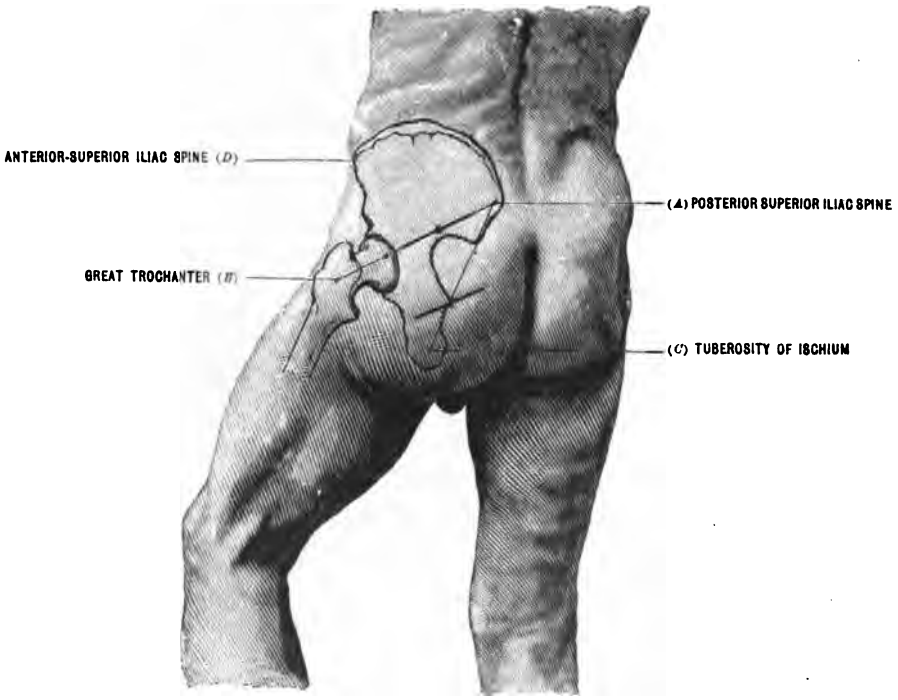
Gluteus maximus.—The 'fold of the buttock' neither corresponds accurately to, nor is caused by, the lower margin of this muscle. Thus, internally, it lies below the lower margin of the muscle, as it runs outwards it crosses it, and externally lies on the muscle. The fold is really due to creasing of the skin adherent here to the coarsely fibro-fatty tissue over the tuber ischii during extension. But in early hip disease, in which flexion of the joint is almost unvaryingly present, both the fold and the gluteus maximus disappear with well-known rapidity. The prominence of the buttock is mainly due to the gluteus maximus, especially behind and below, and in less degree to the other two glutei in front. Under the lower edge of the gluteus maximus the edge of the sacro-tuberous (great sacro-sciatic) ligament can be felt

on deep pressure. To give the surface marking of the gluteus maximus, a line is drawn over the posterior 5 cm. (2 in.) of the iliac crest, thence downwards over the side of the lower part of sacrum and upper part of coccyx. That part of the line between the ilium and sacrum corresponds to the origin from the sacro-tuberous (great sacro-sciatic) ligament. The gluteal ridge into which the lower and deeper part of the muscle is inserted is denoted by a line on the skin just below the back of the great trochanter. Junction of the extremities of the above lines will give the quadrilateral shape of the muscle.

FIG. 1003.—POSITION AND DIRECTION OF THE SUPERFICIAL INCISIONS WHICH MUST BE MADE IN ORDER TO REACH THE SUPERIOR AND INFERIOR GLUTEAL AND PUDIC ARTERIES.

A. B. Ilio-trochanteric line divided into thirds, and corresponding in direction with the line of the gluteus maximus. The incision to reach the gluteus maximus is indicated by the dark part of the line. Its centre is at the position of the upper and middle thirds of the ilio-trochanteric line, and corresponds with the point of emergence of the artery from the great sciatic notch.

A. C. Ilio-ischiatic line. The incision to reach the inferior gluteal (sciatic) or pudic artery is indicated by the lower dark line. This is also to be made in the direction of the fibres of the gluteus maximus. Its centre corresponds to the position of the lower and middle thirds of the ilio-ischiatic line.



Nerves and vessels.—The following **superficial nerves** can be marked in over the buttock (fig. 1025): Behind the great trochanter, branches of the lateral cutaneous; coming down over the crest, the lateral cutaneous branch of the last thoracic (about in a line with the great trochanter), and behind this the lateral branch of the ilio-hypogastric. Two or three offsets of the posterior primary branches of the lumbar nerves cross the hinder part of the iliac crest at the outer margin of the sacro-spinalis (erector spinæ). Two or three twigs from the posterior divisions of the sacral nerves pierce the gluteus maximus close to the coccyx and sacrum, and ramify outwards. Finally, over the lower border of the gluteus maximus, turn upwards branches of the posterior cutaneous (small sciatic) and its perineal branch (inferior pudendal), and the fourth sacral nerve.

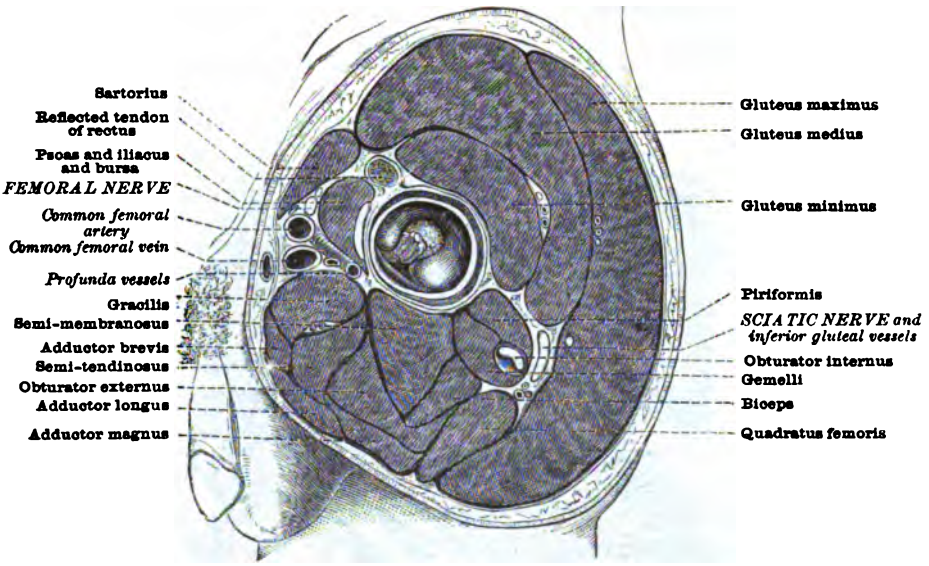
Sciatic nerve (figs. 1005, 1006).—The point of emergence below the gluteus maximus and the track of this nerve (fourth and fifth lumbar and first three sacral nerves) will be given by a line drawn from a spot a little internal to the middle of the space between the great trochanter and the tuber ischii to the lower part of the back of the thigh, where it usually divides into the tibial and common peroneal (internal and

external popliteal) nerves. To stretch the nerve, an incision about three inches long is made in the line of the nerve, beginning about 3·7 cm. (1½ in.) below the gluteus maximus. The long head of the biceps which covers the nerve and which is descending from within outwards, is drawn inwards. If the nerve is exposed lower down, the interval between the hamstrings is identified and these muscles drawn aside. The perineal branch of the posterior cutaneous (inferior pudendal) perforates the deep fascia about 25 mm. (1 in.) in front of the tuber ischii, and turns forwards to supply the genitals.

Superior gluteal artery.—If a line be drawn from the posterior superior spine to the apex of the great trochanter, the limb being slightly flexed and rotated inwards, the point of emergence of the artery from the upper part of the great sacro-sciatic notch will correspond with the junction of the upper and middle third of this line (fig. 1003). (MacCormac.) The gluteal nerve emerges immediately below the artery, and sends branches into the deeper portion.

Inferior gluteal (sciatic) and pudic arteries.—The limb being rotated inwards, a line is drawn from the posterior superior spine to the outer part of the tuber ischii. The point of exit of the above arteries will correspond to the junction of the middle and lower thirds of this line. (MacCormac.)

FIG. 1004.—SECTION THROUGH THE HIP AND GLUTEAL REGION. (One-third.)



THE KNEE

Bony landmarks.—The patella, the condyles of the femur, the condyles and tuberosity of the tibia, the head of the fibula, are all easily examined.

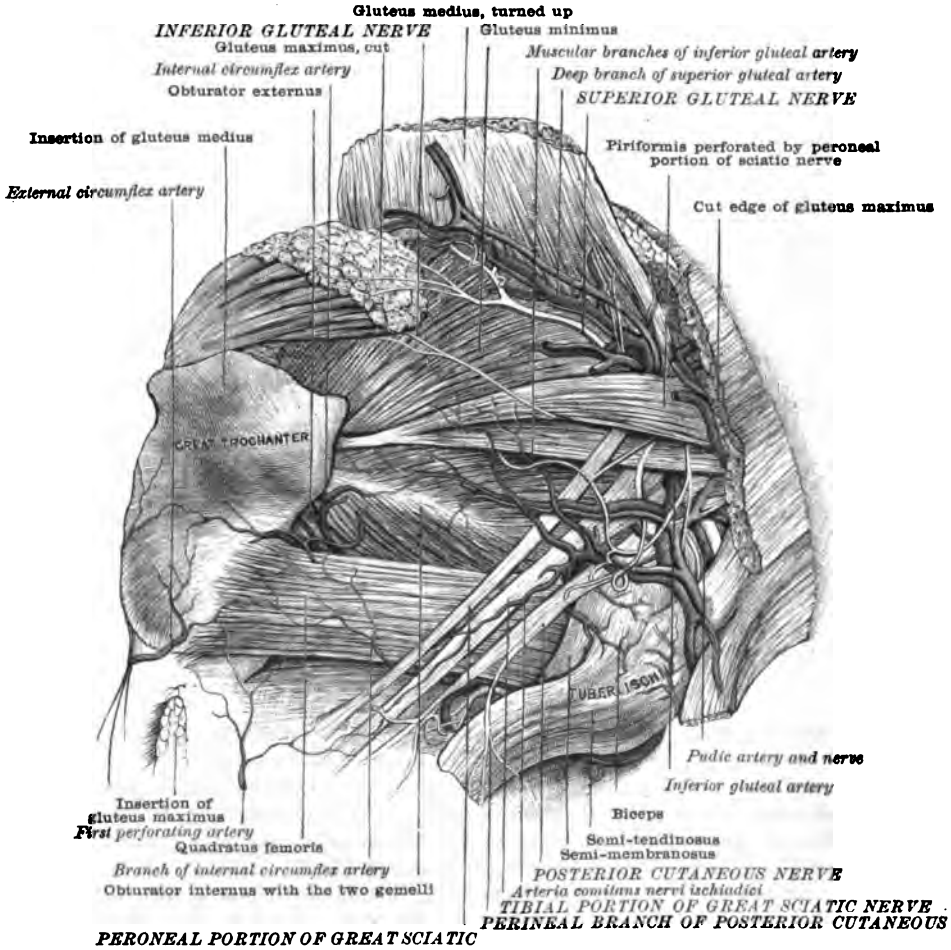
The patella.—The limb being supported in the straight position, and the extensor muscles relaxed, the natural range of mobility laterally of the patella can be estimated. This is interfered with by muscular action in inflammatory conditions, or by early tuberculous ulceration of the contiguous cartilages. The numerous longitudinal striæ or sulci on the anterior surface of this bone can now also be detected. In these are embedded tendinous bundles of the rectus, so as to give firmer leverage. The fact that these fibres, thus tied down, are liable after stretching and tearing to fold in between the ends of the bone after fracture, is a ready explanation of the difficulty of ensuring bony union here. (Macewen.) The patella is separated from the tibia by a pad of fat and a deep bursa, save at its insertion. Owing to the lowest part of the patella being thus separated from the joint by fat, fracture here does not, necessarily, open the joint. The bone has the following relation to the femur in different positions:—(1) In **extension,** the patella rises over the condyles, and in full extension only the lower third of its articular surface rests upon that of the condyles; its upper two-thirds lies upon the bed of fat which covers the lower and front part of the femur. (2) In extreme **flexion,** as the prominent anterior surface of the condyles affords leverage to the quadriceps, the patella needs to project very

little; thus, only its upper third is in contact with the femur, its lower two-thirds now resting on the pad of fat between it and the tibia. (3) In **semiflexion** the middle third of the patella rests upon the most prominent part of the condyles. (Humphry.) While the bone now affords the greatest amount of leverage to the quadriceps, it is also submitted to the greatest amount of strain from this muscle, which is acting almost at a right angle to the long axis of the patella. This position may therefore be called the 'area of danger,' as, in a sudden and violent contraction, the patella may be snapped across by muscular action, aided by the resistance given by the condyles, in the same way as a stick is snapped across the knee. The

FIG. 1005.—THE GLUTEAL REGION, WITH THE SUPERIOR AND INFERIOR GLUTEAL AND PUDIC ARTERIES.

(From a dissection by W. J. Walsham in St. Bartholomew's Hospital Museum.)

The muscular branch of the inferior gluteal (sciatic) artery has been drawn inwards over the tuber ischii with the reflected origin of the gluteus maximus muscle.



amount of separation of the fragments in a fracture of the patella is due chiefly to the extent to which the lateral tendinous expansions of the vasti are torn; to a less degree to the hæmorrhage from the numerous articular vessels (p. 1379) and synovial effusion. The lower fragment is usually the smaller, and its fractured surface tilted forwards; that of the upper one usually looks backwards. Below its articular surface for the femur the patella is separated from the tibia by a pad of fat and a deep bursa, save at the apex, to which the ligamentum patellæ is attached. The patella, the largest of the sesamoid bones, ossifies by a centre which appears from the third to the fifth year. The process is completed about puberty. The rareness with

which necrosis and caries occur here, when the exposed situation of the bone is remembered, is partly explained by the density of its tissue, especially in front, and the intimate blending of the rectus fibres with its periosteum. When the knee-joint is bent, the trochlear surface of the femur can be made out, with some difficulty, underneath the quadriceps expansion. The upper and outer angle of this surface forms a useful landmark (Godlee), as a line drawn from it to the adductor tubercle marks the level of the lower epiphysis of the femur.

Dislocation of the patella.—The following anatomical facts account for this taking place much more frequently outwards:—(1) The inner edge of the patella is more prominent, and thus more exposed to injury; it is also well supported, as is seen when, the parts being relaxed, the fingers are insinuated beneath each border. (2) The pull of the extensor upon the patella, ligamentum patellæ, and tibia is somewhat outwards, as the tibia is directed a little outwards to the femur, to meet the inward direction of this bone; the femora being directed inwards here, to bring the knee-joints nearer the centre of gravity, and, so, counterbalance their wide separation above at the pelvis. The outward pull of the quadriceps upon the patella is, in all normal action of the muscle, counteracted by the space taken in the trochlear surface by the external condyle, this being wider and creeping up higher, and having a more prominent and thus protective lip. In violent contraction, however, these counteracting points may be overcome.

The condyles of the femur and tibia.—It should be noted that on the inner side the prominence of the internal condyle of the femur is well marked, and that of the tibia is less so, while on the outer side this condition is reversed. Descending to the outer condyle (tuberosity) of the tibia, the ilio-tibial band of the fascia lata can be traced. The more distinct outer condyle is a good landmark for opening the joint in amputation and excision. It also indicates the lower level of the synovial membrane of the knee-joint. Farther back are the biceps and fibular lateral (long external lateral) ligament. The gap on the inner side between the femoral and tibial condyles is the place for feeling for a displaced internal fibro-cartilage in 'internal derangement' of the knee, and also for 'lipping' in suspected osteoarthritis. On each femoral condyle, posteriorly, in a thin subject, can be felt its tubercle, which gives attachment to the lateral ligament. Owing to their being placed behind the centre of the bone, these ligaments become tight in extension. On the upper part of the internal femoral condyle the adductor tubercle and the vertical tendon of the adductor magnus can be felt during flexion. This bony point is a guide to the lower epiphysis, the ossification of which and its occasional exostosis have been mentioned at p. 1371. The inner aspect of this condyle faces practically in the same direction as the head of the femur.

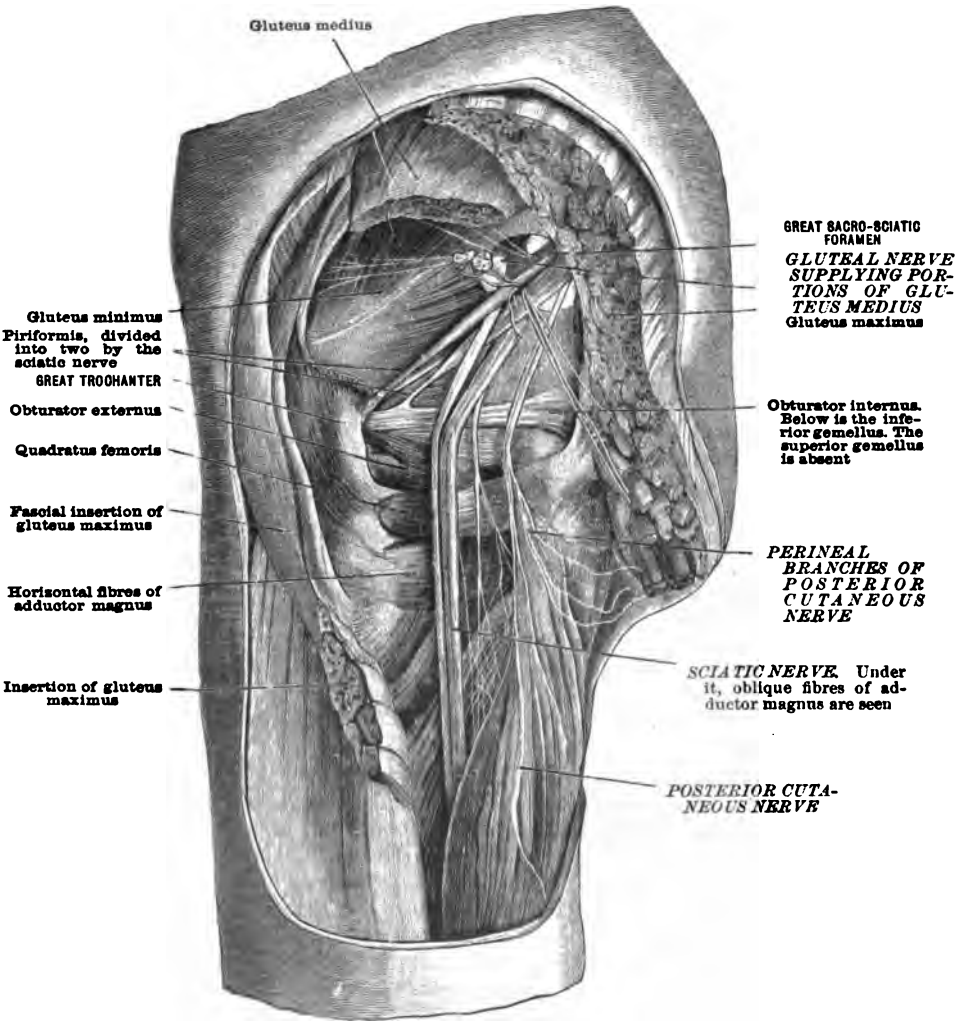
Ligamentum patellæ and tuberosity of tibia.—These, in a well-formed leg, should, with the centre of the ankle-joint, be all in the same straight line, a useful point in the adjustment of fractures. (Holden.) Behind the upper half of the ligament is the infrapatellar pad of fat; below, the lower half is separated from the tibia by a deep bursa. The tuberosity (tubercle) of the tibia is on a level with the head of the fibula.

Prepatellar bursa.—This usually protects the lower part of the patella and upper part of the ligamentum patellæ. It is liable to be enlarged in those who habitually kneel much, the enlargement being either fluid or solid, and occasionally, in tertiary syphilis. Its close connection with the patella and, at the sides, with the joint itself, is to be remembered in infective inflammations of the bursa. Usually the deep fascia, passing off from the sides of the patella upwards to the thigh and downwards to the leg, serves to conduct inflammation away from the joint.

Synovial membrane (fig. 1008).—This, the largest of the synovial membranes, forms a short *cul-de-sac* above the patella, between the quadriceps extensor and the front of the femur, this process reaching about 25 mm. (1 in.) above the trochlear surface of the femur. At its highest point this *cul-de-sac* communicates with another synovial, bursa-like sac lying between the quadriceps and front of the femur. Thus, synovial membrane will usually be met with 62 mm. (2½ in.) or more above the trochlear surface or the upper border of the patella when the limb is extended. Flexing the joint draws the membrane down very slightly. During extension, the above pouch is supported by the articularis genu (subcrureus). At the sides the membrane extends up under the expansions of the vasti for about 75 mm. (3 in.) on the inner and rather less on the outer side; lower down it reaches laterally to near the inner and outer margins of the condyles. Traced downwards, the membrane reaches the level of the head of the tibia, being separated in the middle line

from the upper part of the ligamentum patellæ by fat. It here gives off to the intercondyloid notch the patellar synovial fold (ligamentum mucosum), with its free lateral prolongations, the alar folds (ligamenta alaria). These three so-called ligaments contain fat, the processes not only padding gaps, but also meeting concussions. The enlargement of these processes, under conditions not yet understood, may certainly be a cause of 'internal derangement,' and simulate a loosened meniscus. But the synovial membrane of this joint is not only the largest: it is also the most complicated, a fact accounting for the grave peril of infective arthritis, and the well-known difficulty of effective drainage and cleansing this joint. Thus 'it passes over

FIG. 1006.—DEEP DISSECTION OF THE GLUTEAL REGION. (From a preparation in the Hunterian Museum.)

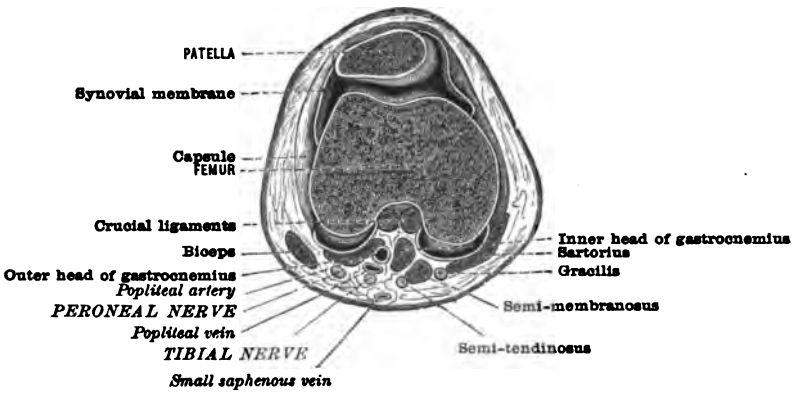

Gluteus medius
GREAT SACRO-SCIATIC FORAMEN
GLUTEAL NERVE SUPPLYING PORTIONS OF GLUTEUS MEDIUS
Gluteus maximus
Gluteus minimus
Piriformis, divided into two by the sciatic nerve
GREAT TROCHANTER
Obturator externus
Quadratus femoris
Fascial insertion of gluteus maximus
Horizontal fibres of adductor magnus
Insertion of gluteus maximus
Obturator internus. Below is the inferior gemellus. The superior gemellus is absent
PERINEAL BRANCHES OF POSTERIOR CUTANEOUS NERVE
SCIATIC NERVE. Under it, oblique fibres of adductor magnus are seen
POSTERIOR CUTANEOUS NERVE

the greater portion of the crucial ligaments, but the posterior surface of the posterior crucial, which is connected by means of fibro-areolar tissue to the front of the ligamentum posticum, and the lower portions of both crucial ligaments, where they are united together, of course cannot receive a complete covering from the membrane.' (Morris.) From the above ligaments the membrane is conducted, lining the lower part of the capsule and other ligaments, to the semilunar cartilages, first over their upper surfaces to their free borders, and then along their under surfaces to the tibia. Between the outer of these and the upper and back part of the tibia is a prolongation of the synovial membrane to facilitate the play of the popliteus

tendon. The special folds, with their packing of fat, the alar folds (ligamenta alaria), and the patellar synovial fold (ligamentum mucosum), passing between the femur and patella, have been mentioned above. Finally, amid the complications of this synovial membrane, its communication with some of the bursæ mentioned below, and occasionally with the superior tibio-fibular joint, is to be borne in mind. In effusion the bony prominences are obliterated, and the patella 'floats.' The knee-joint is easily opened by free lateral incisions lying midway between the margins of the patella and the tuberosities of the condyles, drainage-tubes being passed so as to meet above the patella. The above-mentioned complications of the synovial membrane show that such drainage will be often inadequate. By passing a director to the back of the joint and cutting down upon it carefully from the popliteal space, better drainage will be given, but opening the joint by an anterior flap is needed where the above fail, and, even then, cleansing of the numerous deep recesses is obviously difficult.

Structures on the head of the tibia.—From before backwards these are:—(1) Transverse ligament. (2) Anterior end of internal meniscus (fibro-cartilage). (3) Lower attachment of anterior crucial. (4) Anterior end of external meniscus (fibro-cartilage), blending with (3). (5) Posterior extremity of external meniscus (fibro-cartilage) giving off a strong process to posterior crucial. (6) Posterior extremity of internal meniscus. (7) Posterior crucial ligament. *Menisci.*—These serve

FIG. 1007.—HORIZONTAL SECTION OF THE KNEE-JOINT. (One-half.)



as buffer-bands and cushions between the contiguous bones. The more frequent displacement of the internal is explained by—(*a*) its greater fixity, and, therefore, its feeling strains more. Thus, in addition to weaker attachments to the coronary and transverse ligaments, it is connected all along its convex border with the inside of the capsule, and strongly with the tibial (internal) lateral ligament. The outer fibro-cartilage, on the other hand, is more weakly attached to the capsule, especially opposite to the popliteus tendon, and has no tie to the fibular (external) lateral ligament. (*b*) When, in the erect position, the knee-joint is rotated outwards and slightly flexed, a common position, an especial strain is thrown upon the very important internal lateral ligament, and from the above-mentioned connection, on the internal fibro-cartilage also.

Position of knee-joint in disease.—In inflammatory effusion, the position which best accommodates the collection of fluid is one of moderate flexion, the ligaments being now mainly relaxed. Later on, when the ligaments are softened, the hamstrings obstinately displace the leg backwards, the tibia being rotated outwards by the biceps or inwards by the popliteus and the inner hamstrings. The antero-posterior displacement is always more marked than the lateral. In straightening an anchylosed joint, the resistance of the shortened lateral, crucial, and posterior ligaments, and the facility with which a softened upper epiphysial line of the tibia may give way, must never be forgotten. **Erasion and Excision.**—The extent and complications of the synovial membrane render attention to the following points imperative:—(1) Free exposure of the joint usually by an anterior curved incision, the inner extremity of which must not damage the great saphenous vein. (2) The extension of the pouch under the quadriceps, it may be for 5 cm. (2 in.) above the patella, and the lateral recesses under the vasti. The pouches at the back of the joint are far more difficult to deal with, viz., the partial covering of the posterior crucial ligament, the proximity of the popliteal artery, the pouches in relation to the popliteus, gastrocnemii, and back of the femoral condyles. In erasion, the cartilage and bone, where

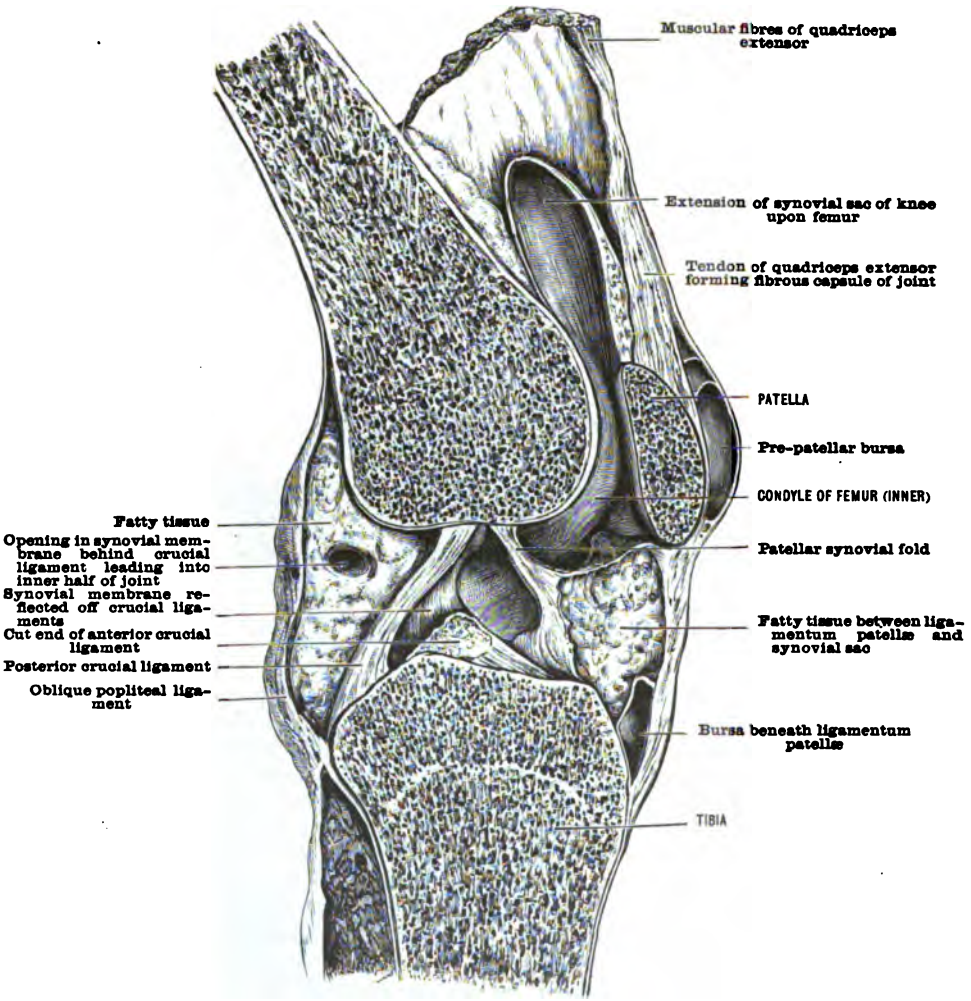
diseased, are removed with a gouge. Owing to the removal, in addition to the synovial membrane, of the fibro-cartilages, and crucial ligaments, and the damage to lateral and patellar ligaments, there is a most obstinate tendency to flexion afterwards. In **excision,** to avoid injury to the epiphysis, the section of the femur should not pass higher than through the upper third of the trochlear surface. Of the tibia, only 12 mm. (½ in.) should be removed.

Genu valgum.—Here the natural angle at which the femur inclines inwards to the tibia is increased. As shown by the late v. Mikulicz, this is due to an abnormal growth downwards of the inner part of the femoral diaphysis, the epiphysial line being gradually altered from one at right angles to the shaft to one which runs obliquely from without downwards and inwards. The femur is not only elongated on its inner side, but bent at its lower end, the concavity of the

FIG. 1008.—VERTICAL SECTION OF THE KNEE-JOINT IN THE ANTERO-POSTERIOR DIRECTION.

(The synovial bursa usually present above the upper synovial *cul-de-sac* is not shown.)

(The bones are somewhat drawn apart.)


Muscular fibres of quadriceps extensor
Extension of synovial sac of knee upon femur
Tendon of quadriceps extensor forming fibrous capsule of joint
PATELLA
Pre-patellar bursa
CONDYLE OF FEMUR (INNER)
Fatty tissue
Opening in synovial membrane behind crucial ligament leading into inner half of joint
Synovial membrane reflected off crucial ligaments
Cut end of anterior crucial ligament
Posterior crucial ligament
Oblique popliteal ligament
Patellar synovial fold
Fatty tissue between ligamentum patellæ and synovial sac
Bursa beneath ligamentum patellæ
TIBIA

curve being outwards. Other changes have to be remembered. Pes valgus very commonly coexists, and in the tibia there may be a compensatory curve, the concavity being inwards, in the lower third, or an analogous alteration in the line of the upper epiphysis may be present, its direction being no longer at a right angle with the shaft, but oblique. In Sir W. Macewen's supra-condyloid osteotomy, a longitudinal incision, about 37 mm. (1½ in.) long is made where the following lines meet, viz., one transverse, a finger's breadth above the upper margin of the external condyle, and one longitudinal, 12 mm. (½ in.) in front of the adductor magnus tendon. The incision is made down to the bone, the osteotome introduced by the side of the knife and then rotated until its edge is transverse to the shaft. The osteotome is at first driven outwards and forwards, and, when the bone is about half cut through, outwards transversely. The small bridge of bone on the outer side is left to be broken. With the above-given precautions, the bone is divided in front of the genu suprema (anastomotica) and above the superior internal

articular artery, above the epiphysial line and behind and posterior to the upward extension of the synovial membrane under the quadriceps.

The following **bursæ about the knee-joint** must be remembered. Some, it will be seen, are much more constant than others:—

A. **In front.**—(1) One between the patella and skin, the bursa prepatellaris subcutanea (fig. 1008); (2) a deeper one between the ligamentum patellæ and the upper part of the tibia; (3) between the skin and the lower part of the tubercle of the tibia. This is not constant.

B. **On the inner side.**—(1) One between the inner head of the gastrocnemius and inner condyle, often extending between the above muscle and the semi-membranosus. This is the largest of the bursæ about the knee-joint, and, after adult life, usually communicates with the knee-joint. But, owing to the narrow communication, it is rarely possible, when the parts are relaxed by flexion of the joint, to empty the cyst. For its removal a straight incision is made over the most prominent part of the swelling, its neck found by drawing aside the tendons. A ligature is then pushed high up around the neck, and the cyst cut away. (2) One superficial to the tibial (internal) lateral ligament, between it and the tendon of the sartorius, gracilis, and semi-tendinosus. (3) One beneath the ligament, between it and the tendon of the semi-membranosus. (4) One between the inner condyle (tuberosity) of the tibia and the semi-membranosus. (5) One between the semi-membranosus and semi-tendinosus. Of the above bursæ, the first two alone are constant. The second and third are often one bursa prolonged.

C. **On the outer side.**—(1) One between the outer head of the gastrocnemius and the condyle; (2) one superficial to the external lateral ligament between it and the biceps tendon; (3) one under the ligament between it and the popliteus tendon; (4) one between the popliteus tendon and the outer condyle of the femur. This is usually a diverticulum from the synovial membrane.

The following explanations may be given of an inflamed knee-joint usually taking the flexed position:—(1) By experimental injections, Braune found that the capacity of the synovial sac reaches its maximum with a definite degree of flexion, i. e., at an angle of twenty-five degrees. (2) As the same nerves supply the synovial membrane and the muscles, flexors, extensors, adductors, which act upon the joint, the flexors being more powerful than the extensors, will help to explain the flexed position. (Hilton.)

Anastomoses around the front and sides of the knee-joint.—The most important of these take the form of **three transverse arches.** (1) The **highest** passes through the quadriceps fibres just above the upper edge of the patella. It is formed by a branch from the deep division of the genu suprema (anastomotica magna) and one from the external circumflex and superior external articular. The middle and lowest arches lie under the ligamentum patellæ. (2) The **middle arch,** formed by branches from the genu suprema and superior internal articular on the inner side, and the inferior external articular, on the outer, runs in the fatty tissue close to the apex of the patella. (3) The **lowest arch** lies on the tibia just above its tuberosity (tubercle), and results from the anastomosis of the recurrent tibial and the inferior internal articular. Seven arteries thus take place in this series of anastomoses.

POPLITEAL SPACE

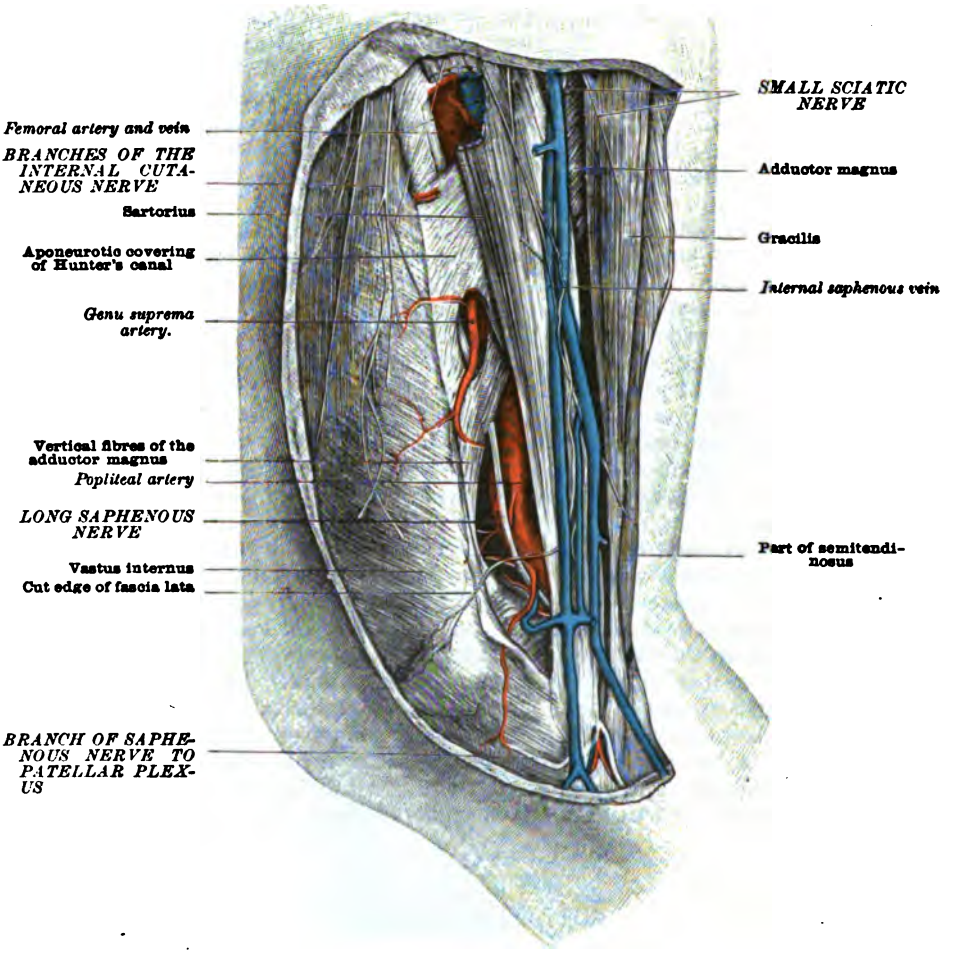
In flexion, the **hollow of this space** appears; in extension it is obliterated and its boundaries are ill-defined, the only ones now to be made out being the semi-tendinosus and the biceps.

Popliteal tendons.—When the knee is a little bent and the foot rests on the ground, the following can be made out:—At the outer side, behind the ilio-tibial band, and descending to the prominence on the outer side of the head of the fibula, is the tendon of the biceps. This prominence also gives attachment to the fibular (external) lateral ligament, which splits the tendon into two parts. Behind is the apex (styloid process) from which the posterior part of the fibular lateral ligament arises. Parallel and close to the inner border of the tendon, the peroneal nerve descends, as a rounded cord, to cross the neck of the fibula and enter the peroneus longus. In subcutaneous tenotomy of the biceps, the knife should be introduced

between the nerve and the tendon, and made to cut from within outwards, and thus away from the nerve. But the open method has the great advantage of ensuring precision and the division of any contracted fascial bands. On the inner side the tendons are thus arranged: Nearest to the middle of the popliteal space is the long and more slender tendon of the semi-tendinosus; next, the thicker tendon of the semi-membranosus; this and the gracilis, which comes next, appear as one tendon, but by a little manipulation the finger can be made to sink into the interval between the semi-membranosus, with its thick rounded border externally and the gracilis internally. The sartorius can easily be thrown into relief on the inner side of the

FIG. 1009.—SIDE VIEW OF THE POPLITEAL ARTERY.

(From a dissection in the Hunterian Museum.)



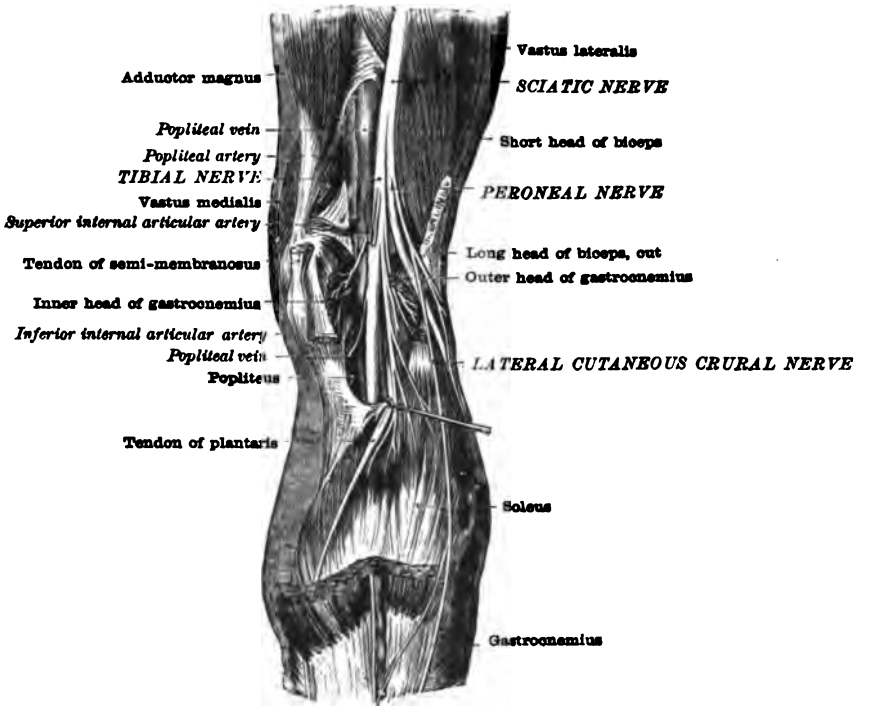
joint by telling the patient to raise the leg extended, the limb being rotated outwards and one leg crossed over the other.

Popliteal vessels.—The **artery** traverses this space from above downwards, appearing beneath the semi-membranosus, a little to the inner side of the middle line, and then passing down in the centre of the space to the interval between the gastrocnemii. Its course corresponds with a line drawn from the inner side of the hamstrings to the centre of the lower part of the space. The artery bifurcates on the level of a line corresponding to the tuberosity (tubercle) of the tibia. It lies on the popliteal surface of the femur, the oblique popliteal (posterior) ligament and the popliteus. It is the second of these structures which usually prevents popliteal

aneurism and abscess from making their way into the joint. The **popliteal vein,** intimately adherent to the artery, lies to the outer side above, but crosses to its inner side below. The popliteal sheath is also unusually strong. The tibial (internal popliteal) nerve crosses the artery in the same direction as the vein, by which it is separated from the artery. This nerve is the direct continuation of the sciatic nerve (fig. 1010), and enters more into the space than its fellow branch. The close relation of the vein and nerve explains the early stiffness of the knee, the pains below, often called 'rheumatic,' and the œdema, in popliteal aneurism; also the pulsation of swellings not aneurismal.

The **superior articular arteries** (fig. 1010) course outwards and inwards immediately above the femoral condyles; the way in which they cling closely to the bone here is one provision to prevent overstretching of the artery; the **inferior** ones lie just above the head of the fibula and below the internal condyle of the tibia (fig. 1010). The deep part of the genu suprema (anastomotica magna) artery runs in front of the tendon of the adductor magnus; the superficial with the saphenous nerve.

FIG. 1010.—DEEP VIEW OF THE POPLITEAL SPACE. (Hirschfeld and Leveillé.)



The **popliteal artery may be ligatured**—(A) **Behind,** in the upper part of the popliteal space, just after its emergence from under the semi-membranosus. Here, for a short space of about 2·5 cm. (1 in.), the vessel is comparatively superficial after division of the fasciæ. The nerve is generally seen first, and, with the vein, must be drawn outwards. The needle should be passed from the vein. (B) **From the front,** at the inner side. The thigh being flexed, abducted, and rotated outwards, a free incision is made parallel and just behind the adductor magnus tendon, commencing at the junction of the middle and lower third of the thigh. The sartorius and the hamstrings are drawn backwards, and the adductor magnus forwards. Care must be taken of the genu suprema (fig. 1009). The space between the hamstrings and the adductor magnus being carefully opened up, the artery will be found in fatty areolar tissue. The vein and tibial nerve are on the outer side of the vessel. The needle is passed from without inwards. The collateral circulation (p. 1370) depends chiefly on the genu suprema.

The small (**external**) **saphenous vein** perforates the roof of the popliteal space in its lower part. As a rule, it is not visible, unless enlarged.

The **popliteal nodes** are not to be felt unless enlarged.

Bursæ in the popliteal space.—These have been already spoken of (p. 1379).

THE LEG

The skin.—The proneness of this to dermatitis in the lower third of the inner and front aspect of the leg as a result of varicose veins is well known. The close contiguity of the periosteum to the skin here accounts for the difficulty in healing chronic ulcers whose callous base has become fixed to the periosteum, and the tenacity with which the upper fragment of a fractured tibia may perforate the skin.

Bony landmarks.—From the tuberosity (tubercle) of the tibia descends the anterior border or 'shin.' This soon becomes sharp, and continues so for its upper two-thirds; in the lower third it disappears, to be overlaid by the extensor tendons. It is curved somewhat outwards above and inwards below. The inner border can also be felt from the inner condyle to the internal malleolus. Between these two borders lies the internal surface, subcutaneous save above, where it is covered by the three tendons of insertion of the gracilis and semi-tendinosus, and, overlying them, that of the sartorius. The tibia is narrowest and weakest at the junction of the middle and lower thirds, the most common site of fracture. Behind the internal malleolus, part of the groove for and the tendon of the tibialis posterior can be felt.

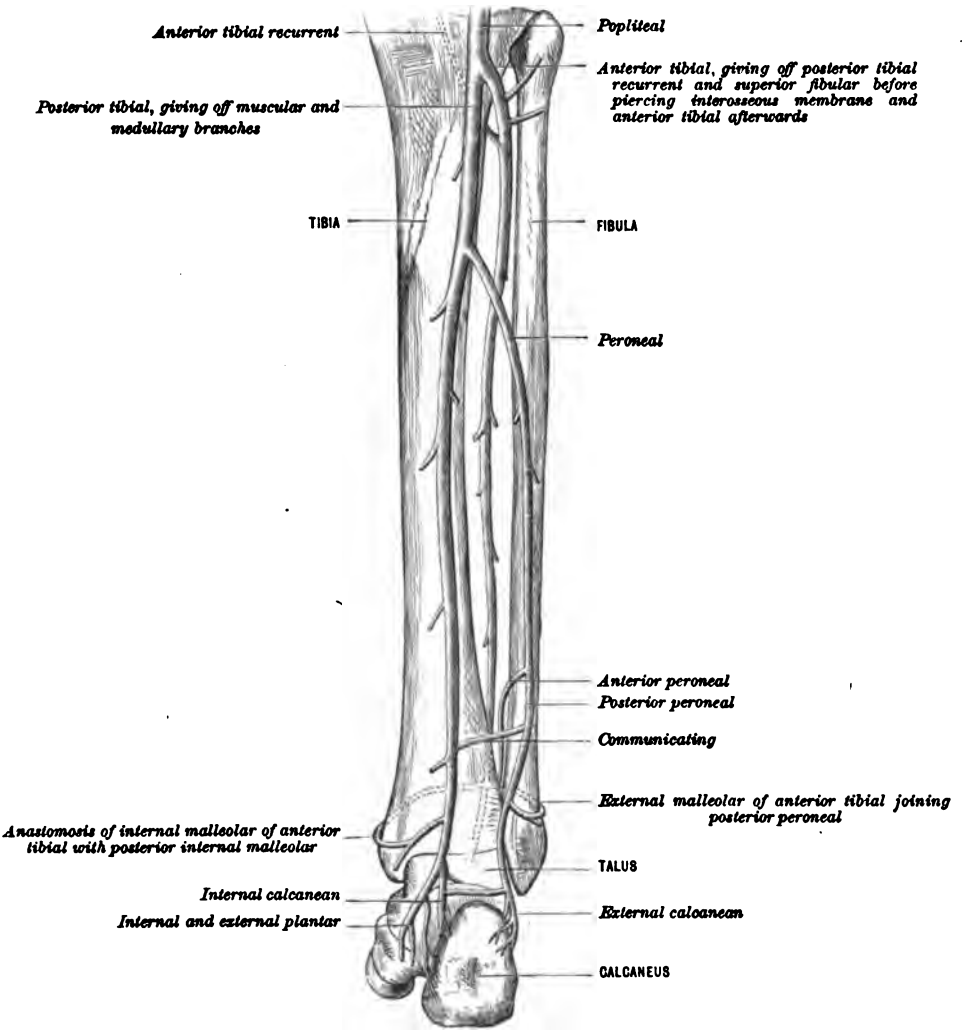
The head of the fibula can be felt distinctly, but the shaft soon becomes buried amongst muscles till about 7·5 cm. (3 in.) above the external malleolus, where the bone expands into a large triangular subcutaneous surface. This lies between the peroneus tertius and the other two peronei. The peroneus longus overlaps the brevis, especially in the upper two-thirds of the leg. In the lower third the brevis tends to become anterior (fig. 1014). Behind the external malleolus these tendons descend to the foot in a groove on its posterior border. The shaft of the fibula is placed on a plane posterior to that of the tibia, and curves backwards in a direction reverse to that of the tibia.

Muscular compartments and prominences.—When the muscles of the leg are thrown into action by dorsi-flexion and plantar flexion of the foot or by standing on the toes, several groups of muscles stand out on the surface, owing to certain **compartments,** and the origin of certain muscles from, and their separation by, the deep fascia, which knits the surface into corresponding elevations and depressions. The bones and the two peroneal septa divide the leg into four **compartments.** These are, from within outwards:—(1) An **internal,** corresponding to the internal surface of the tibia. (2) An **anterior,** between the crest of the tibia and the anterior peroneal septum, attached to the antero-external border of the fibula, and separating the extensors from the peronei. Its surface-marking would be a line from the front of the head of the fibula to the front of the external malleolus. In this anterior compartment lie the extensor muscles and origin of the peroneus tertius, and the anterior tibial vessels and nerves. (3) An outer or peroneal compartment, lying between the anterior and posterior peroneal septum, the latter being attached to the postero-external border of the fibula, and separating the peronei from the calf and deep flexors. This peroneal compartment, a narrow one, contains the two chief peronei and the peroneal (external popliteal) nerve and its three divisions. (4) Much the largest, this, the **posterior,** lies between the posterior peroneal septum and the inner border of the tibia, and contains the calf and deep flexor muscles, the posterior tibial vessels and nerves, and the peroneal artery and its posterior branch. The space between the tibia and fibula is mainly occupied by the fleshy belly of the tibialis anterior; outside this, and much less prominent, is the narrower extensor digitorum longus; outside this, again, are the peronei longus and brevis. Lower down, in an interval between the tibialis and the extensor of the toes, the extensor hallucis, here almost entirely tendinous, comes to the surface. Behind, the prominence of the calf is mainly formed by the gastrocnemius. On the patient's rising on tip-toe, the tendo Achillis starts into relief from about the middle of the leg. Of the two heads of the gastrocnemius, the inner is seen to be the larger. On either side of the tendon, but more distinctly on the outer side, where it is less overlapped by the gastrocnemius, the soleus comes into view. Its muscular fibres

are continued on the deep surface of the tendon to within a short distance of the heel. Between the tendon and the upper part of the os calcis is a bursa, occasionally the seat of effusion, as in gonorrhœa.

The bones.—Their relative position and curves have been mentioned (p. 1382). **Access.**—That to the **tibia** is easy along the inner aspect. The **fibula** is best explored by a free incision along the line of the posterior peroneal septum, which lies between the peronei and the muscles at the back (p. 1382). The presence of the superficial peroneal (musculo-cutaneous) nerve perforating the deep fascia in the lower third below and that of the common peroneal (external popliteal) in relation to the neck of the fibula above, must be remembered. **Fractures.**—When,

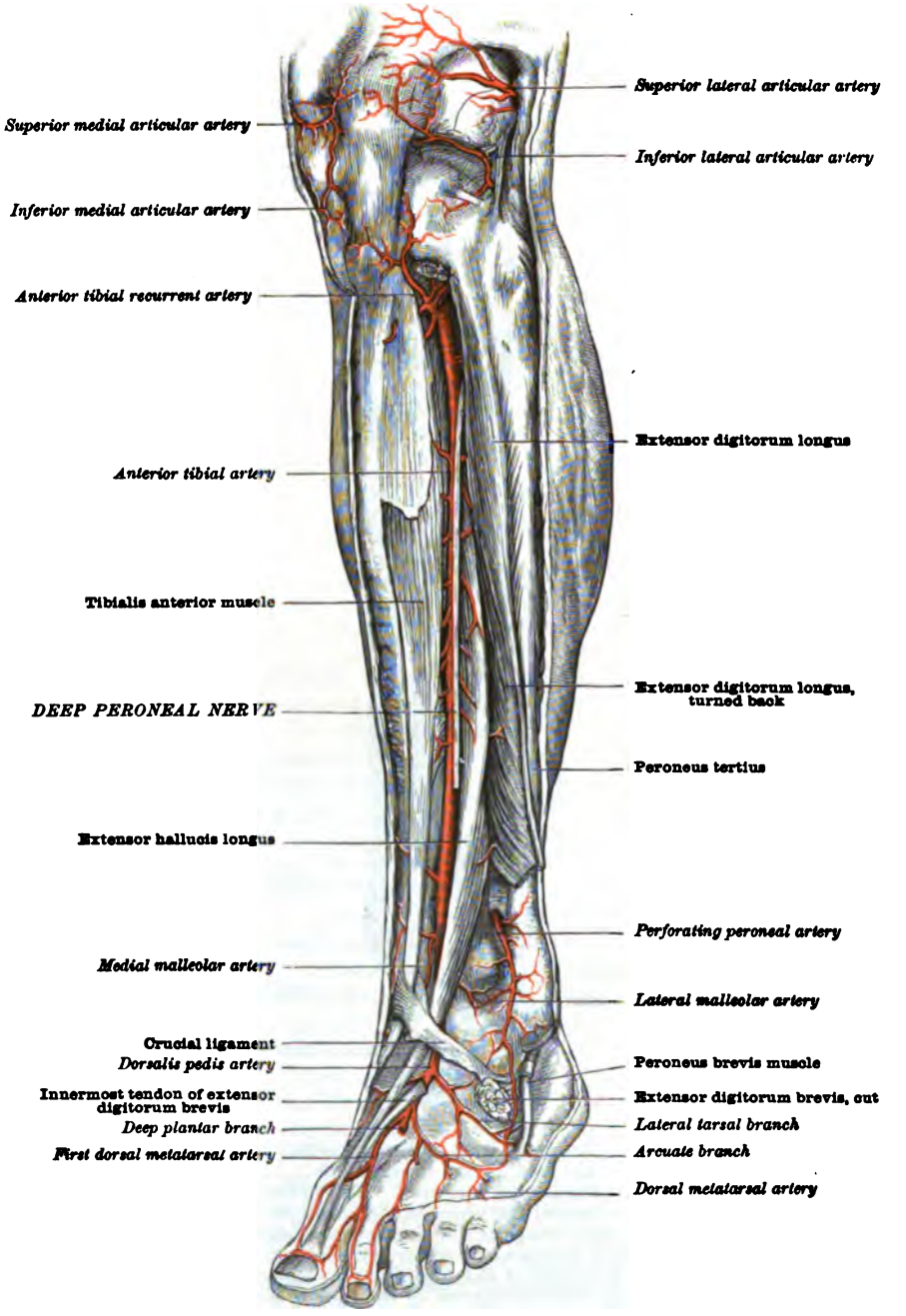
FIG. 1011.—ANASTOMOSES OF TIBIAL ARTERIES.



as is most frequent, the tibia gives way from indirect violence, the fracture is usually at the weakest spot, or the junction of the middle and lower thirds. The line of obliquity is generally marked, and from above downwards and forwards. The lower fragment, pulled upwards by the powerful calf muscles, rides behind the upper, which projects forwards under the skin. The fibula, bending more than the tibia, snaps at a higher level. Tenderness on pressure is the best guide here, as it is in suspected fractures of the upper tibia, transverse from direct violence. The most common variety of **fracture of the fibula** is that called after **Pott,** complicated with displacement of the foot. Here, from abduction of the foot, a severe strain is thrown upon the internal lateral ligament, which gives way; the talus (astragalus) is pressed against the external malleolus, and the inferior tibio-fibular ligaments resisting, the fibula yields 5 to 7 cm. (2 to 3 in.) above the ankle, the upper end of the lower fragment being usually displaced towards the tibia. If the internal lateral ligament is strong, the strain often tears off the internal malleolus. The inner margin of the foot is turned towards the ground, the outer raised. The foot is also displaced backwards. On the inner side of the ankle there is a marked projection of the lower end of the tibia; higher up, on the outer side, a depression where the fibula is broken. The

need of replacing the foot and the weight-bearing talus (astragalus) accurately, the fact that the ankle-joint is opened and the numerous tendons likely to be matted, are the chief points to bear in mind. In **Dupuytren's fracture** there is not only fracture of the lower end of the fibula, but the interior tibio-fibular ligaments are now torn. The foot is displaced upwards

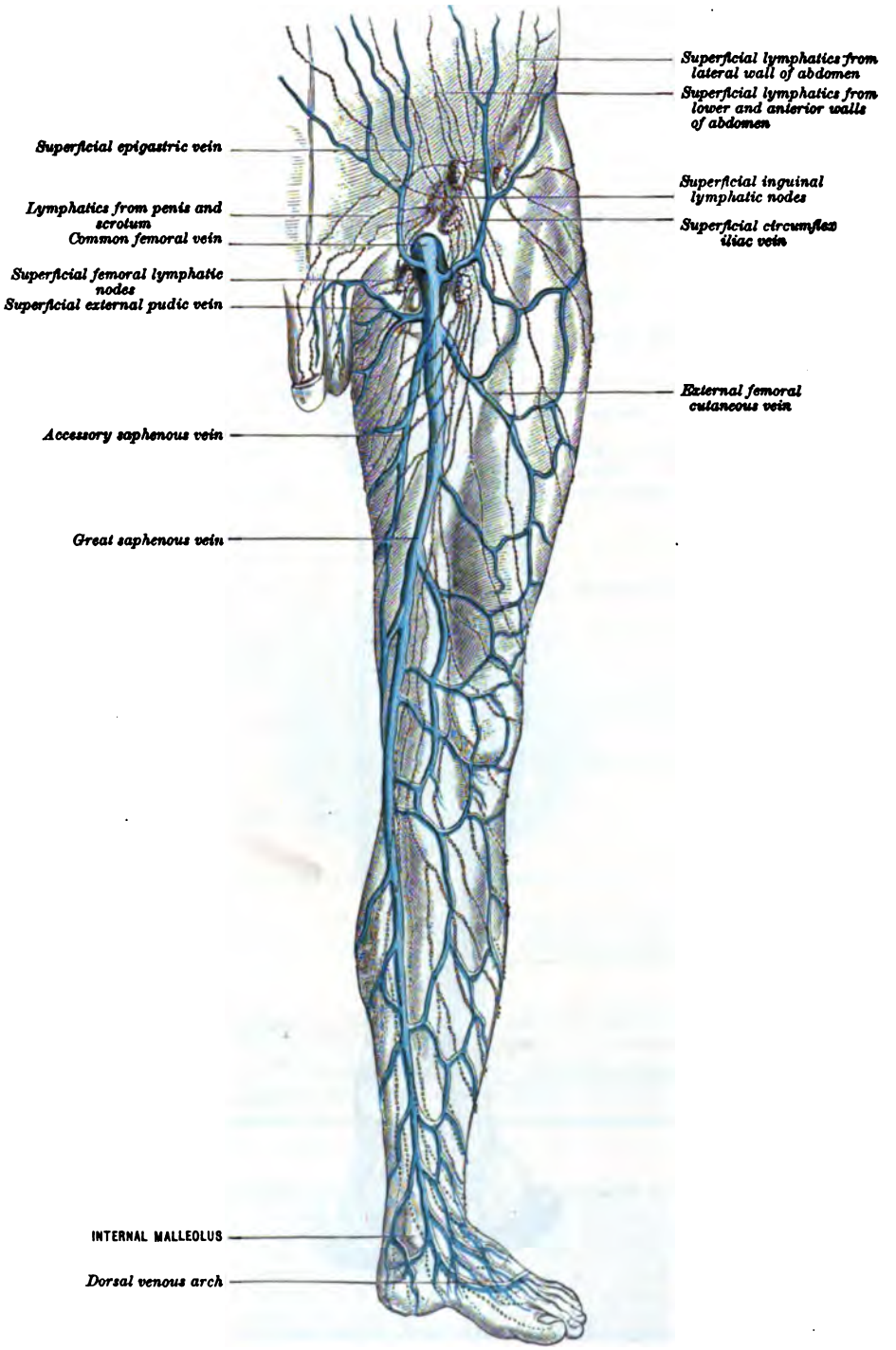
FIG. 1012.—THE ANTERIOR TIBIAL ARTERY, DORSAL ARTERY OF THE FOOT, AND PERFORATING BRANCH OF THE PERONEAL ARTERY, AND THEIR BRANCHES.



and outwards, together with the lower end of the fibula. **Epiphyses.**—The upper one of the tibia appears before birth and includes the condyle and tuberosity. It does not fuse with the shaft till the age of twenty or later. This fact and the powerful strain of the rectus on this epiphysis explain the obscure pain sometimes complained of in young adults much given to athletics, along the line of junction. The lower epiphysis, including the internal malleolus, appears in

the second and joins about the eighteenth year. Separation here is not very uncommon up to puberty. In osteotomy of the tibia, simple or cuneiform, when the curve is antero-posterior as well as lateral, the close vicinity of the tibialis anterior tendon to the outer border of the crest

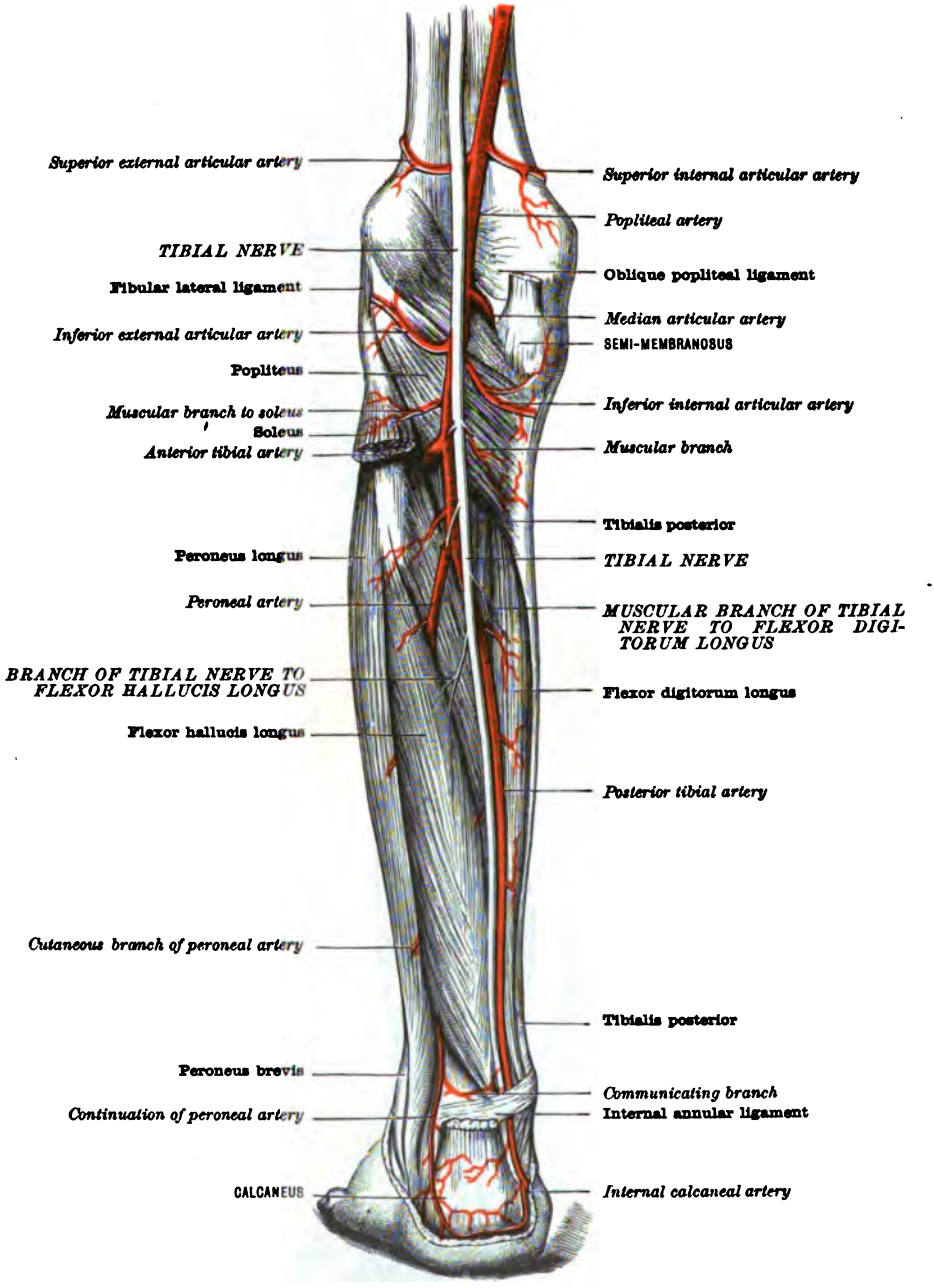
FIG. 1013.—THE SUPERFICIAL VEINS AND LYMPHATICS OF THE LEFT LOWER LIMB.


Superficial lymphatics from lateral wall of abdomen
Superficial lymphatics from lower and anterior walls of abdomen
Superficial epigastric vein
Superficial inguinal lymphatic nodes
Lymphatics from penis and scrotum
Superficial circumflex iliac vein
Common femoral vein
Superficial femoral lymphatic nodes
Superficial external pudic vein
External femoral cutaneous vein
Accessory saphenous vein
Great saphenous vein
INTERNAL MALLEOLUS
Dorsal venous arch

must be remembered, and when the fibula does not yield to careful force, it, also, must be divided, or damage may be done to the superior and inferior tibio-fibular ligaments, or to the epiphyses of the bones.

Vessels.—The **saphenous veins** should be carefully traced, owing to the tendency of these and their branches to become varicose. The **great (internal)** (figs. 1000 and 1013), having passed from the arch on the dorsum over the internal malleolus, runs up close to the inner border of the tibia, where it is to be avoided

1014.—Relations of the Popliteal Artery to Bones and Muscles.
(The peroneal artery is here made too large.)



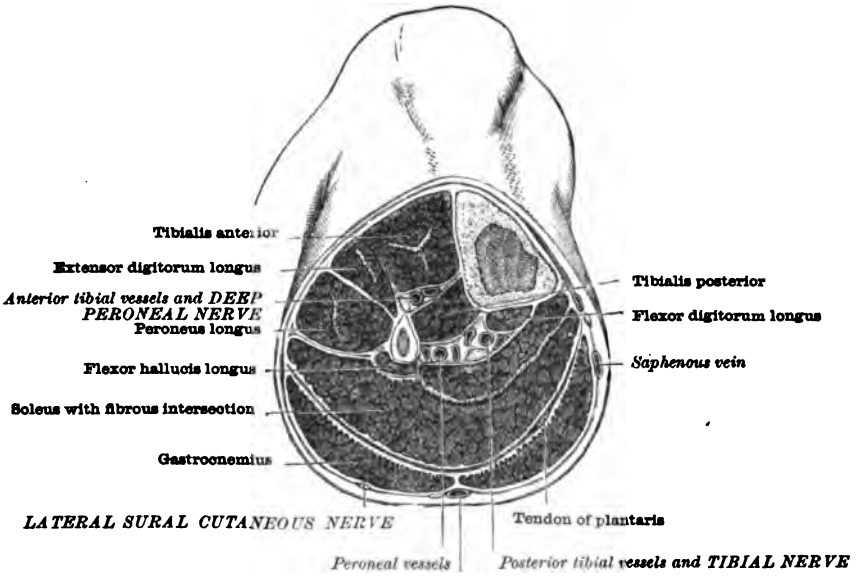
in ligature of the posterior tibial, to the back of the internal condyle; here this vessel is to be remembered in operations on the knee-joint; then upwards along the thigh, over the roof of the adductor (Hunter's) canal, to the fossa ovalis (saphenous opening) (p. 1369 and fig. 1013), where it joins the femoral by perforating the cribriform fascia and the femoral sheath. Four to six valves are present, chiefly in the

upper part. The 'dangerous area,' or that in which thrombosis is most likely to occur, reaches from the centre of the thigh to the middle of the leg. (Bennett.) The saphenous nerve joins the vein below the knee, having been under the sartorius above this point (p. 1370 and fig. 1002). The surface-marking of the upper part of the vein is a line drawn from the posterior border of the sartorius or the adductor tubercle to the lower part of the fossa ovalis (saphenous opening). The **small (external)** saphenous vein passes behind the external malleolus, runs upwards over the middle of the calf, and joins the popliteal by perforating the deep fascia in the lower part of the popliteal space. This vein is accompanied by the medial sural cutaneous (external saphenous) nerve throughout its course.

The **popliteal artery** bifurcates at the lower border of the popliteus, about on a level with the tuberosity of the tibia. About 5 cm. (2 in.) lower down the peroneal artery comes off from the posterior tibial (fig. 1014).

The course of the **posterior tibial** corresponds with a line drawn from the centre of the lower part of the popliteal space to a point midway between the tip of the internal malleolus and the inner edge of the calcaneus. In the lower third, the

FIG. 1015.—SECTION OF THE RIGHT LEG IN THE UPPER THIRD. (Heath.)



artery becomes more superficial, passing from beneath the calf muscles, lying between the tendo Achillis and inner border of the tibia, and only covered by the skin, deep fascia, and, lower down, by the laciniate (internal annular) ligament. It is here, in its close relation to the tendons of the tibialis posterior and flexor digitorum longus, that it is liable to be injured in the older methods of tenotomy. The nerve is internal above, external below (fig. 1014).

Ligature of the posterior tibial in the middle of the leg.—The following are the chief points in the technique. An incision, 7·5 to 10 cm. (3 to 4 in.) long, is made 12 mm. (½ in.) behind the inner border of the tibia, to avoid the trunk of the great saphenous. The deep fascia being freely opened, the inner head of the gastrocnemius is drawn backwards. The tibial attachment of the soleus, thus exposed, is cut through carefully, so as to allow of identification of its central membranous tendon, which must not be confused with the deep intermuscular septum over the flexor. Any sural vessels are now tied. The above-mentioned special septum is next made out, passing between the bones (vertical line descending from oblique line of tibia and postero-internal or oblique line of fibula). On division of this septum the nerve usually comes into view, the artery lying more external. The needle is passed from the nerve; the venæ comites may be included. The muscles should now be fully relaxed by flexion of knee and plantar flexion of foot. The ligature will be placed below the peroneal artery.

The course of the **anterior tibial artery** corresponds with a line drawn from a point midway between the outer condyle of the head of the tibia and the head of the fibula to one on the centre of the ankle-joint. This line corresponds to the outer border of the tibialis anterior and the interval between it and the extensor digitorum longus (figs. 1011 and 1012). This is shown when the first of these muscles is thrown into action. The accompanying nerve is in front above, external below.

Ligature of the anterior tibial artery at the junction of the upper and middle thirds of the leg. The limb being flexed and rotated inwards, an incision is made, 7·5 to 10 cm. (3 to 4 in.) long, in the line of the artery, distant 2·5 cm. (1 in.) or more (according to the size of the leg) from the crest, and beginning about 5 cm. (2 in.) below the head of the tibia. If, on exposure of the deep fascia, the intermuscular septum between the tibialis and long extensor of the toes is not well defined, the fascia must be freely slit up in the line of the artery, and the sulcus felt for. A small muscular artery may lead down to the trunk. The foot is now dorsiflexed and the artery sought for deep on the interosseous membrane. The nerve should be drawn to the outer side. The venæ comites may be included in the ligature.

In **senile gangrene** the liability of the tibial arteries to disease and consequent thrombosis and interference with the collateral circulation accounts both for the extension of the disease and the difficulty in detecting pulsation.

The **peroneal artery,** given off from the posterior tibial about an inch below the popliteus, or three inches below the head of the fibula, runs deeply along the inner border of this bone, covered by the flexor hallucis longus, the nerve to which accompanies the vessel. It gives off the anterior peroneal, through the interosseous membrane, to the front of the external malleolus about an inch above the level of the ankle-joint. Its continuation, as the posterior peroneal, runs behind the malleolus, to join the anastomosis about the ankle-joint.

The **nutrient artery** of the tibia arises from the posterior tibial near its commencement. It is the largest of all the nutrient arteries to the shafts of long bones; that for the fibula comes from the peroneal.

As a general rule, in **amputation** 2·5 cm. (1 in.) below the head of the fibula, only one main artery—the popliteal—is divided. In amputations 5 cm. (2 in.) below the head of the fibula, two main arteries—the anterior and posterior tibials—are divided. In amputations 7·5 cm. (3 in.) below the head, three main arteries—the two tibials and the peroneal—are divided. (Holden.)

In an amputation through the middle of the leg, the anterior tibial artery would be found cut on the interosseous membrane between the tibialis anterior and the extensor hallucis longus, the deep peroneal nerve here reaching the outer side of the vessel. The posterior tibial would be between the superficial and deep muscles at the back of the leg lying on the tibialis posterior, its nerve being to the outer side. The peroneal would be close to the fibula in the flexor hallucis longus,

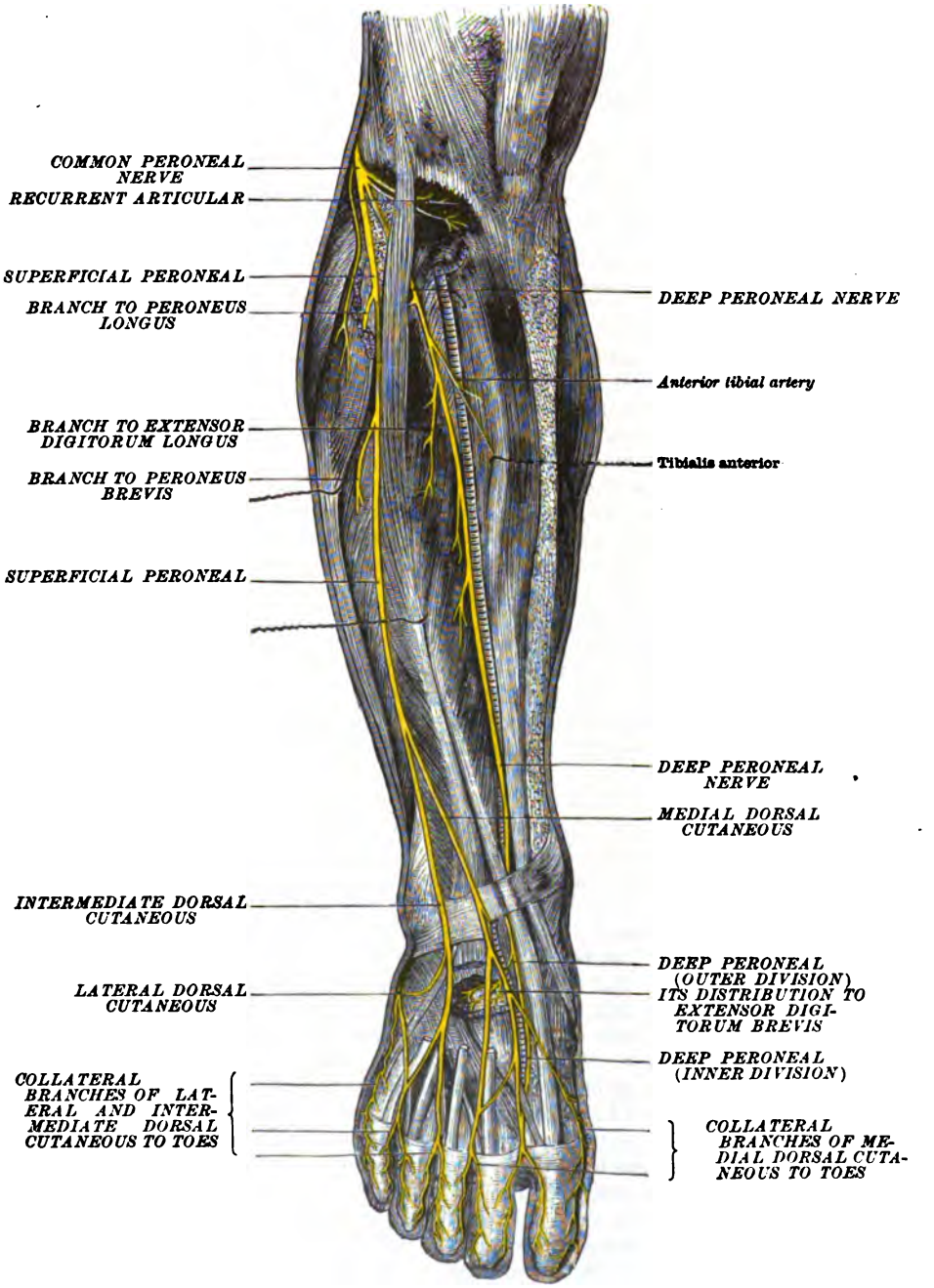
The **superficial peroneal** (musculo-cutaneous) nerve, having passed through the peroneus longus and then between the peroneus longus and peroneus brevis, perforates the deep fascia in the lower third of the leg in the line of the septum between the peronei and extensors. Directly after, it divides into its two terminal branches.

Amputation of the leg.—To give one instance only, amputation 'at the seat of election,' or a hand's-breadth below the knee-joint, will be alluded to. Lateral skin-flaps and circular division of the muscles give an excellent result in hospital practice where the various conditions which call for such a step are usually met with. The above name was given because the pressure of the body is well carried on the prominences about the knee-joint, especially the tuberosity (tubercle) of the tibia, when the patient walks with the knee flexed on a 'bucket' artificial limb. Thus the scar, being central, is here not of importance. Two broadly oval lateral flaps of skin and fasciæ are raised, and the remaining soft parts severed down to the bones with circular sweeps of the knife. In sawing the bone, the smaller size of the fibula and its position behind the tibia must be remembered. It is well, in order to ensure complete division of the fibula first, to roll the limb well over on its inner side, and place the saw well down on the outer side. If it is desired to amputate lower down, and thus preserve the movements of the knee-joint, M. Farabeuf's modification of the above is a useful one: A large hooded antero-external flap is raised, including all the structures down to the interosseous membrane, the anterior tibial artery being raised down to the end of the flap. On the inner side the two extremities of the base of the flap are joined by a short incision going down to the bone. In both cases it is well to round off the crest of the tibia. The vessels, especially above, need care in their isolation before they are tied. Their position has been given above. The parts cut through are shown in fig. 1015.

THE ANKLE

Bony landmarks.—Malleoli.—The following are the differences between them: The **internal** is the more prominent, shorter, and is placed more anteriorly than the outer, being a little in front of the centre of the joint. The **external** descends lower by about 12 mm. (½ in.), and thus securely locks in the joint on this

FIG. 1016.—BRANCHES OF THE EXTERNAL POPLITEAL NERVE.


COMMON PERONEAL NERVE
RECURRENT ARTICULAR
SUPERFICIAL PERONEAL
BRANCH TO PERONEUS LONGUS
BRANCH TO EXTENSOR DIGITORUM LONGUS
BRANCH TO PERONEUS BREVIS
SUPERFICIAL PERONEAL
INTERMEDIATE DORSAL CUTANEOUS
LATERAL DORSAL CUTANEOUS
COLLATERAL BRANCHES OF LATERAL AND INTERMEDIATE DORSAL CUTANEOUS TO TOES
DEEP PERONEAL NERVE
Anterior tibial artery
Tibialis anterior
DEEP PERONEAL NERVE
MEDIAL DORSAL CUTANEOUS
DEEP PERONEAL (OUTER DIVISION) ITS DISTRIBUTION TO EXTENSOR DIGITORUM BREVIS
DEEP PERONEAL (INNER DIVISION)
COLLATERAL BRANCHES OF MEDIAL DORSAL CUTANEOUS TO TOES

side; it is opposite to the centre of the ankle-joint, being placed about 12 mm. (½ in.) behind its fellow. Owing to the external malleolus descending lower than the inner, in Syme's and Pirogoff's amputations the plantar incision should run

between the tip of the external malleolus and a point 12 mm. (½ in.) below that of the internal one. When a fracture is set, or a dislocation adjusted, the inner edge of the patella, the internal malleolus, and the inner side of the great toe are useful landmarks and should be in the same vertical plane, regard being paid at the same time to the corresponding points in the opposite limb. (Holden.)

On the posterior aspect of the internal malleolus is a groove for the tibialis posterior and flexor digitorum longus, the first named being next the bone. The tip and borders of the process give attachment to the deltoid ligament. The anterior border and tip of the external malleolus give attachment to the anterior and middle bands of the external lateral ligament, the posterior fasciculus arising from a pit behind and below the articular facet. The posterior border is grooved for the two peronei. The line of the ankle-joint corresponds to one about 12 mm. (½ in.) below the tip of the internal malleolus.

Effusion of tuberculous thickening shows itself first at two points, between the internal malleolus and tibialis anterior and between the peroneus tertius and external malleolus. Owing to the thinness of the transverse crural (anterior) ligament, the extensor sheaths are easily affected in neglected tuberculous disease. Owing to the way in which the joint is locked in, it is not easy to open and drain an infected ankle-joint satisfactorily. Removal of a portion of the external malleolus subperiosteally, leaving the tip and external lateral ligament, will admit of the insertion of a tube and good drainage if the foot is so slung as to keep its outer aspect dependent.

Tendons.—(A) **In front of ankle.**—From without inwards are—(1) The tibialis anterior, the largest and most internal. This tendon appears in the lower third of the leg, lying just under the deep fascia, close to the tibia; then, crossing over the lower end of this and the ankle-joint, it passes over the inner side of the tarsus, to be attached to the inner and lower part of the first (internal) cuneiform and the adjacent part of the first metatarsal. (2) The extensor hallucis longus. This tendon, concealed above, appears low down in a line just external to the last, and then, crossing over the termination of the anterior tibial vessels and nerves (to which its muscular part lies external), it descends along the inner part of the dorsum to be attached to the base of the last phalanx of the great toe. (3) and (4) The extensor digitorum longus and peroneus tertius enter a common sheath in the transverse crural (anterior annular) ligament. The former then divides into four tendons, which, joined on the first phalanx by slips, three from the extensor brevis, and, a little later, by slips from the lumbricales and interossei, are inserted into the second and last phalanges, as in the fingers. The peroneus tertius is inserted into the upper surface of the base of the fifth metatarsal bone.

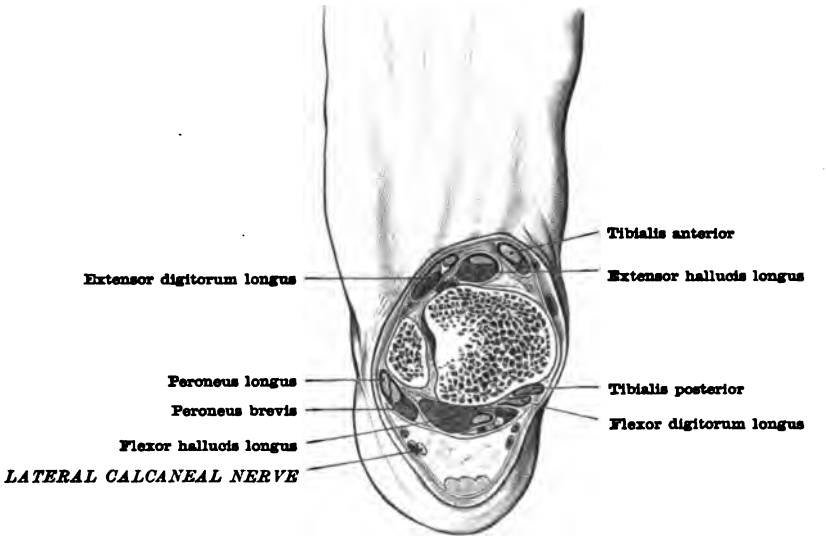
(B) **Behind.**—The tendo Achillis, the thickest of all tendons, begins near the middle of the leg, in the junction of the tendons of the gastrocnemii and, a little lower, (p. 1384) the soleus. Very broad at its commencement, it gradually narrows and becomes very thick. About 3·7 cm. (1½ in.) from the heel, or about the level of the internal malleolus, is its narrowest point. After this it again expands slightly, to be attached to the middle of the back part of the calcaneus. The long tendon of the plantaris runs along its inner side, to blend with it or to be attached to the calcaneus. On either side of the tendo Achillis are well-marked furrows below. Along the inner, the tendon of the tibialis posterior and the posterior tibial vessels and nerve come nearer the surface. Along the outer, the small (external) saphenous vein (more superficially) ascends from behind the external malleolus.

(C) **On the inner side.**—The tendon of the tibialis posterior, which has previously crossed from the interspace between the bones of the leg to the inner side, lies behind the inner edge of the tibia above the internal malleolus, then behind this, being here under the flexor digitorum longus, the two tendons having become superficial on the inner side of the tendo Achillis. It then passes forwards over the internal lateral and under the laciniate (internal annular) ligament between the internal malleolus and the sustentaculum tali, and then below and close to the plantar calcaneo-navicular (inferior calcaneo-scaphoid) ligament (*vide infra*), and so to its insertion, by numerous slips, into the tarsus and metatarsus, especially the tuberosity of the navicular. The tendon of the flexor hallucis longus cannot be felt. Having passed internally from the fibula, it crosses the lower end of the tibia in a separate furrow, then grooves the back of the talus (astragalus), and passes under the sustentaculum tali on its way to its insertion. The arrangement of the

structures at the inner ankle from above downwards, and from within outwards, is as follows (fig. 1017):—tibialis posterior, flexor digitorum longus, companion vein, posterior tibial artery, companion vein, tibial nerve, flexor hallucis longus. The tibiales posterior and anterior turn the sole inwards, antagonising the peroneus longus. Their action on the arch of the foot is mentioned at p. 1298. The flexors not only act upon the toes, but aid the calf muscles in straightening the foot upon the leg in walking or standing upon tip-toe; hence the value of educating them in cases of flat-foot.

(D) **Tendons at outer ankle.**—The tendons of the two peronei, which arise from the fibula between the extensor digitorum longus and flexor hallucis longus, pass behind the external malleolus, the brevis being nearer to the bone (fig. 1017). They then pass forwards over the outer surface of the calcaneus, separated by the peroneal tubercle when present, and diverge. The brevis—the upper one—passes to the projection at the base of the fifth metatarsal; the longus, lying below the brevis on the calcaneus, winds round the outer border of the foot, grooving the outer border and under surface of the cuboid. Finally, crossing the sole obliquely forwards and inwards, it is attached to the adjacent parts of the first (internal) cuneiform and the back part and under surface of the first metatarsal. While in

FIG. 1017.—TRANSVERSE SECTION THROUGH THE LOWER THIRD OF THE LEFT LEG, IMMEDIATELY ABOVE THE ANKLE-JOINT. (Braune.)



connection with the under surface of the cuboid, this tendon is covered in by a sheath from the long plantar ligament, and often contains a sesamoid bone. The two peronei evert the foot, as is seen in talipes valgus and in fracture of the lower end of the fibula; the peroneus longus aids in the support of the arch of the foot (p. 1298), and, by keeping the great toe on the ground, is important in the third stage of walking, skating, etc.

Annular ligaments and synovial membranes of tendons.—These strap-like bands of deep fascia, which serve to keep the above tendons in position, are three in number, viz.:—

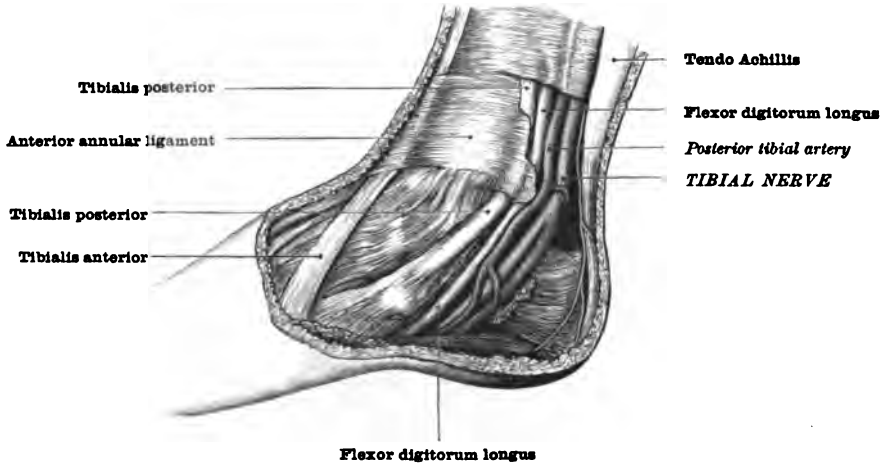
(A) **External.**—This, the superior peroneal retinaculum, extends from the tip of the external malleolus to the outer surface of the calcaneus. It keeps the two peronei in place, and surrounds them behind the fibula in one sheath with a single synovial sac, which extends upwards into the leg for 3·7 cm. (1½ in.), and sends two processes into the two sheaths in which the tendons lie on the calcaneus. Farther on, while in relation with the cuboid, the peroneus longus has a second synovial sheath.

(B) **Internal.**—This, the laciniate ligament, crosses from the internal malleolus to the inner surface of the calcaneus. Beneath it are the following canals:—(1) For

the tibialis posterior. This tendon-sheath is lined by a synovial membrane extending from a point 3·7 cm. (1½ in.) above the malleolus to the navicular. (2) For the flexor digitorum longus. The synovial sheath of this tendon is separate from that of the closely contiguous tibialis posterior. It extends upwards into the leg about as high as the sheath just given. It reaches down into the sole of the foot; but where the tendon subdivides to enter the thecæ, each of these is lined by a separate synovial sheath. Next comes (3) a wide space for the posterior tibial vessels and nerve; and, lastly, (4) a canal, like the other two, with a separate synovial sheath, for the tendon of the flexor hallucis longus. The lower margin of this annular ligament gives an attachment to the abductor hallucis and blends with the plantar fascia. The internal calcaneal vessels and nerve perforate the ligament.

(C) **Anterior annular ligament.**—This is a double structure. (1) **Upper (transverse crural ligament), above the level of the ankle-joint,** and tying the tendons down to the lower third of the leg, passes transversely between the anterior crest of the tibia and fibula. Here is one sheath only, with a synovial membrane for the tibialis anterior. (2) **Lower, over the ankle-joint.** This band, the cruciate ligament, is arranged like the letter ≺, placed thus. It is attached by its root

FIG. 1018.—RELATIONS OF PARTS BEHIND THE INNER MALLEOLUS. (Heath.)



to the calcaneus, and by its bifurcations to the internal malleolus and plantar fascia. This arrangement of the branches of this ligament is not constant. In this, the lower annular ligament, there are usually three sheaths with separate synovial membranes—the innermost (the strongest in each) for the tibialis anterior, the next for the extensor hallucis longus, and the third common to the extensor communis and peroneus tertius. The extensor digitorum brevis has a partial origin from this ligament.

Points in tenotomy and guides to the tendons.—The **tendo Achillis** should be divided about 3·7 cm. (1½ in.) above its insertion, its narrowest point, which is about on a level with the internal malleolus. The knife should be introduced on the inner side and close to the tendon, so as to avoid the posterior tibial artery (fig. 1018).

The **tibialis anterior** may be divided about 25 mm. (1 in.) above its insertion into the first (internal) cuneiform, a point which is below the level of its synovial sheath. The tendon has here the dorsalis pedis on its outer side, but separated by the tendon of the extensor hallucis longus. The knife is introduced on this side.

The **tibialis posterior.**—The usual rule for dividing this tendon is to take a spot 5 cm. (2 in.) above the internal malleolus, and as accurately as possible midway between the anterior and internal borders of the leg. This point will give the inner margin of the tibia, in close apposition to which the tendon is lying, and is a point at which the tendon is rather farther from the artery than it is below, and is also above the commencement of its synovial sheath. A sharp-pointed knife is used first to open the sheath freely, and then a blunt-pointed one to divide the tendon. The flexor digitorum longus is usually cut at the same time.

Owing to the risk of injury to the posterior tibial vessels, the difficulty of ensuring division of the tendons, the following open method is, nowadays, superior, being more certain, and admitting of division of ligaments, e. g., talo-navicular (astragalo-scaphoid) and anterior part of

internal lateral (syndesmotomy of Parker), which are always contracted in advanced talipes equino-varus. A V-shaped flap with its apex over the first metatarsal bone and its two limbs starting, the lower below the margin of the plantar fascia on a line with the internal malleolus, the upper from a point over the head of the talus (astragalus), is turned backwards. The plantar fascia is divided, the tibialis anterior is found, near its insertion, under the upper lip of the wound, the tibialis posterior and the flexor digitorum longus in the lower, the former close to the navicular. If necessary, the calcaneo- and talo-navicular (astragalo-scaphoid) and anterior part of the internal lateral ligaments can be divided also.

Peronei.—The peronei longus and brevis may be divided 5 cm. (2 in.) above the external malleolus, so as to be above the level of their synovial sheath. The knife should be inserted very close to the bone, so as to pass between the fibula and the tendons. Division below the external malleolus by a small flap is easier.

THE FOOT

Bony landmarks.—The following are of the greatest practical importance, owing to the operations which are performed upon the foot.

(A) **Along the inner aspect of the foot** are the following:—

(1) Internal tuberosity of the calcaneus; (2) internal malleolus; (3) 2·5 cm. (1 in.) below the malleolus, the sustentaculum tali; (4) about 2·5 cm. (1 in.) in front of the internal malleolus, and a little lower, is the tuberosity of the navicular, the inner guide in Chopart's amputation, the gap between it and the sustentaculum being filled by the calcaneo-navicular ligament and the tendon of the tibialis posterior, in which there is often a sesamoid bone; (5) the first (internal) cuneiform; (6) the base of the first metatarsal; and (7) the head of the same bone, with its sesamoid bones below. (Holden.)

(B) **Along the outer aspect** are:—(1) The outer tuberosity of the calcaneus; (2) the external malleolus; (3) the peroneal tubercle of the calcaneus (when present), 2·5 cm. (1 in.) below the malleolus, with the long peroneal tendon below it, and the short one above; (4) the projection of the anterior end of the calcaneus, and the calcaneo-cuboid joint, midway between the tip of the external malleolus and the base of the fifth metatarsal bone; (5) the base of the fifth metatarsal bone; (6) the head of this bone. The greater process of the calcaneus and the muscular origin of the short extensor lie between the peroneus brevis and tertius.

Levels of joints and lines of operations.—The line of the ankle-joint has been given at p. 1389. That of the talo-calcaneal (calcaneo-astragaloid) joint—the limited lateral movements of the foot take place here and at the medio-tarsal joint—corresponds, on the outer side, to a point a little in front of the external malleolus and midway between it and the peroneal tubercle; on the inner side, to one just below the sustentaculum tali. In **Syme's amputation** through the ankle-joint, the incision starts (say in the case of the left foot) from the tip of the external malleolus, and is then carried, pointing a little backwards towards the heel, across the sole to a point 12 mm. (½ in.) below the internal malleolus. The chief supply to the heel-flap is from the internal calcaneal. Care should be taken to divide the posterior tibial below its bifurcation and not to prick this vessel afterwards.

In **Pirogoff's amputation** the incision begins and ends at the same points, but is carried straight across the sole. In each amputation the extremities of the above incision are joined by one going directly across the ankle-joint, which lies about 12 mm.(½ in.) above the tip of the internal malleolus.

In **Chopart's medio-tarsal amputation** (fig. 1019), which passes between the talus (astragalus) and the navicular on the inner side, and the calcaneus and the cuboid on the outer, the line of the joints to be opened would be one drawn across the dorsum from a point just behind the tuberosity of the navicular to a point corresponding to the calcaneo-cuboid joint, just midway between the tip of the external malleolus and the base of the fifth metatarsal bone. The convexity of the plantar flap should reach to a point 2·5 cm. (1 in.) behind the heads of the metatarsal bones. Owing to the tendency of the unbalanced action of the calf muscles to tilt up the calcaneus and thus throw the scar down into the line of pressure, the powerful tibialis anterior tendon and those of the extensors should be carefully stitched into the tissues of the sole flap.

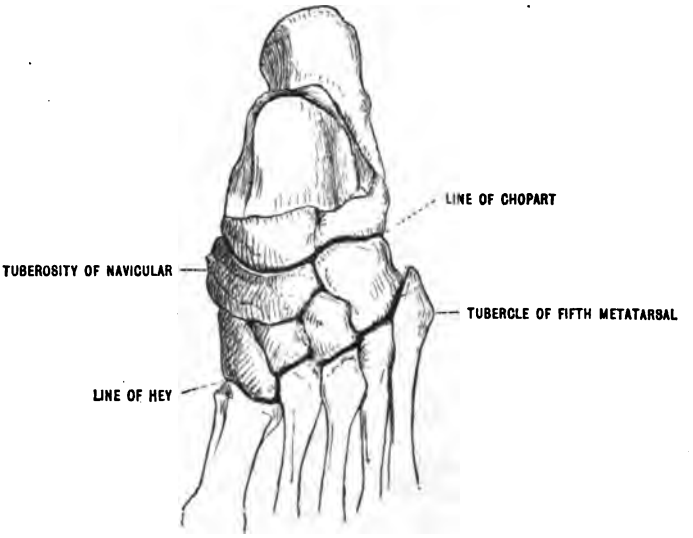
In **Lisfranc's**, or **Hey's**, or the **tarso-metatarsal amputation**, the bases of the fifth and first metatarsals must be defined. The first of these can always be detected, even in a stout or swollen foot; on the inner side the joint between the first (internal) cuneiform and the first metatarsal bone lies 37 mm. (1½ in.) in front of the navicular tuberosity. In opening the joint between the second metatarsal and the middle cuneiform, its position (the base of the former bone projecting upwards on to a level 6 or 8 mm. (¼ or ⅓ in.) above the others), and the way in which it is locked in between its fellows and the cuneiform bones, must be remembered. The convexity of the plantar flap here reaches the heads of the metatarsal bones.

In marking out the flaps for the **amputation of the great toe**, the large size of the head of the first metatarsal, and the importance of leaving this so as not to diminish its supporting power and the treading width of the foot, and thus of marking out flaps sufficiently long and large, must be borne in mind. The dorsal incision should begin 3·7 cm. (1½ in.) above the web. The line of the joint is nearly opposite the centre of the ball of the toe (fig. 1021). The sesamoid

bones should be left, so as not to endanger the vitality of the flaps. In amputation of the other toes, the line of their metatarso-phalangeal joints lies a full inch above the web.

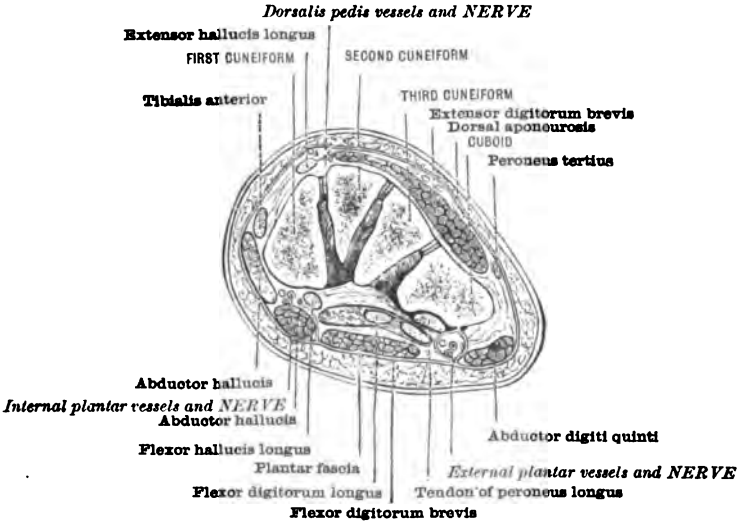
Bursæ and synovial membranes.—The synovial sheath of the extensor hallucis longus extends from the front of the ankle, over the instep, as far as the meta-

FIG. 1019.—ARTICULATIONS OF THE FOOT, DORSAL ASPECT. (Bellamy.)



tarsal bone of the great toe. There is generally a bursa over the instep, above, or it may be below, the tendon. There is often an irregular bursa between the tendons of the extensor digitorum longus and the projecting end of the talus (astragalus) over which the tendons play. There is much friction here. It is well to be aware that this bursa sometimes communicates with the joint of the head of the talus

FIG. 1020.—VERTICAL SECTION THROUGH THE CUNEIFORM AND CUBOID BONES. (One-half.)

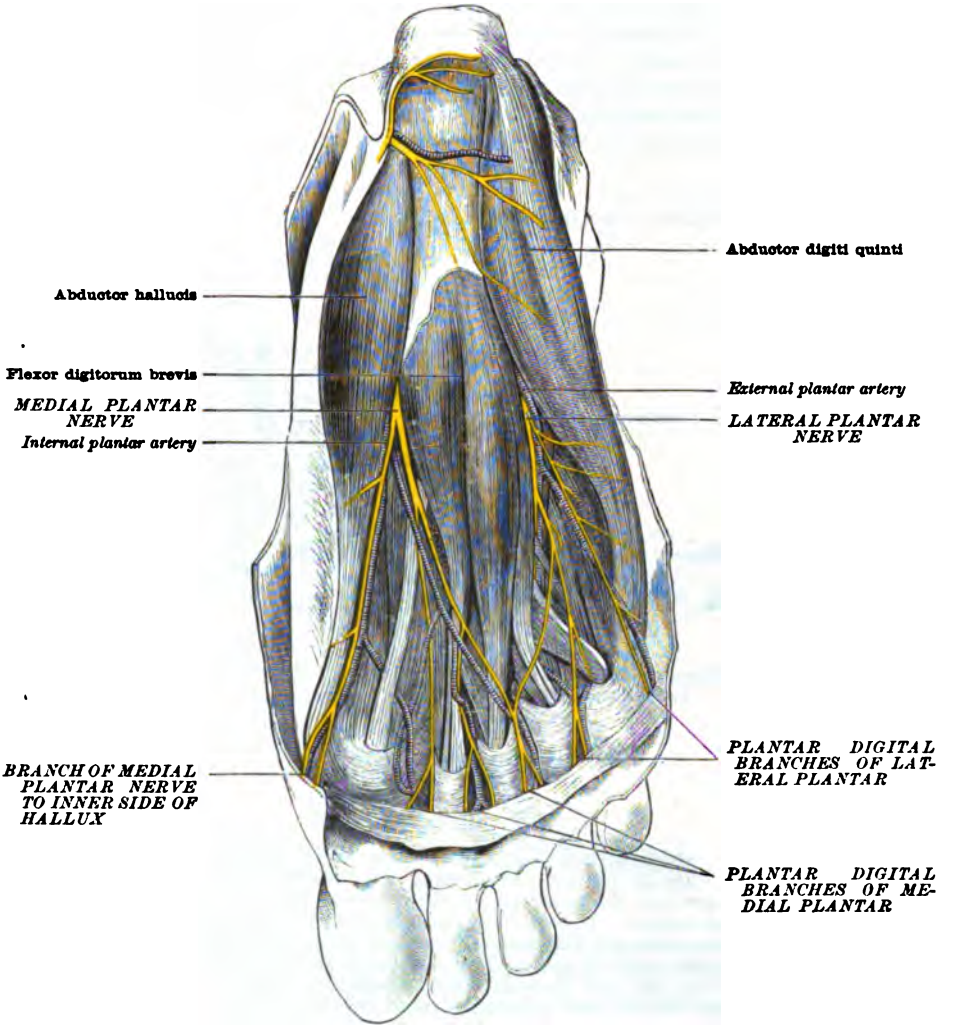


(astragalus). (Holden.) There is a deep synovial bursa between the tendo Achillis and the calcaneus. Numerous other bursæ may appear over any of the bony points in the foot, especially when they are rendered over-prominent by morbid conditions.

Synovial membranes.—In addition to that of the ankle-joint, there are **six** synovial membranes in the **tarsus,** viz.:—(1) Talo-calcaneal (posterior calcaneo-

astragaloid), peculiar to these bones; (2) talo-calcaneo-navicular (anterior calcaneo-astragaloid), common to these bones and the scaphoid; (3) between the calcaneus and the cuboid; (4) between the cuboid and the outer two metatarsals; (5) between the first (internal) cuneiform and the first metatarsal; (6) a complicated and extensive one, which branches out between the navicular and cuneiform bones; between the cuneiforms; between the third (external) cuneiform and the cuboid; between the second (middle) and third (outer) cuneiform and the second and third metatarsal bones; and between the second and third and the third and fourth metatarsal bones.

FIG. 1021.—SUPERFICIAL NERVES IN THE SOLE OF THE FOOT. (Ellis.)


Abductor digiti quinti
Abductor hallucis
Flexor digitorum brevis
MEDIAL PLANTAR NERVE
Internal plantar artery
External plantar artery
LATERAL PLANTAR NERVE
BRANCH OF MEDIAL PLANTAR NERVE TO INNER SIDE OF HALLUX
PLANTAR DIGITAL BRANCHES OF LATERAL PLANTAR
PLANTAR DIGITAL BRANCHES OF MEDIAL PLANTAR

Dorsal artery.—The line of this is from the centre of the ankle-joint to the upper part of the first interosseous space. On its inner side is the tendon of the extensor hallucis longus; on its outer, the innermost tendon of the extensor digitorum longus. It is crossed by the innermost tendon of the extensor brevis. The origin of this muscle should be marked on the outer and fore part of the calcaneus.

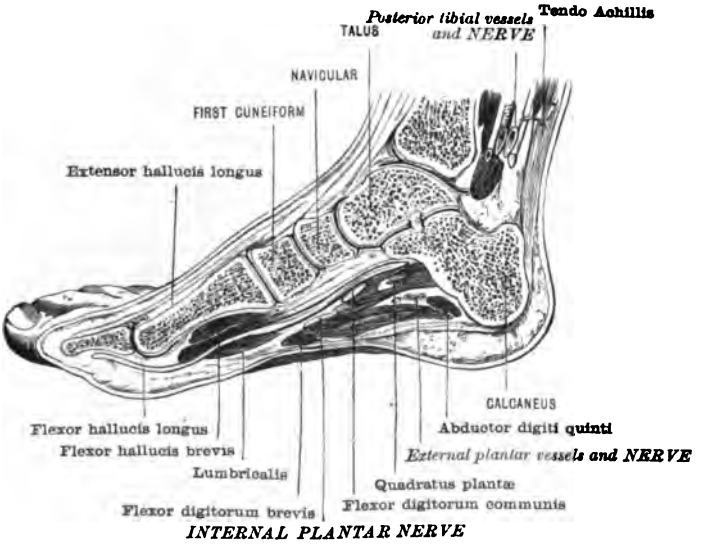
Cutaneous nerves (figs. 1021, 1025).—The sites of these, numerous on the dorsum of the foot, are as follows:—The **superficial peroneal (musculo-cutaneous) nerve,** having perforated the fascia in the lower third of the leg, divides into two chief branches, inner and outer, which supply all the toes save the outer part of the

little, and the adjacent sides of the first and second. The **deep peroneal (anterior tibial)** becomes cutaneous in the first space, and is distributed to the contiguous sides of the above-mentioned toes. The **sural (external saphenous) nerve** runs with its vein below the malleolus, and supplies all the outer border of the foot and the outer side of the little toe. The **(internal) saphenous nerve,** coursing with its vein in front of the internal malleolus, supplies the inner border of the foot as far as the middle of the instep.

Plantar arteries.—The line of the internal would be one drawn from the bifurcation of the posterior tibial, or about midway between the tip of the internal malleolus and the inner border of the heel, to the middle of the plantar surface of the great toe. The course of the external plantar runs in a line drawn from the bifurcation, first obliquely across the foot to a point a little internal to the inner side of the base of the fifth metatarsal, and thence obliquely across the foot till it reaches the first space and joins with a communicating branch from the dorsal artery. It thus crosses the foot twice. In the first part, it is more superficial, in the second very deep; it here forms the plantar arch, and is only separated from the bases of the metatarsals by the interossei.

The anastomosing branches about the ankle-joint are shown in figs. 1011 and 1012.

FIG. 1022.—LONGITUDINAL SECTION OF FOOT. (One-third.) (Braune.)



Tarsal bones.—The chief surgical points about these is the frequency with which they are diseased and their changes in talipes. **Frequency of disease.**—This is explained, chiefly, by their delicate structure and the fact that on the aspect in which they are most exposed to injury the soft parts are scanty. Disease once started, often by slight injury, finds in the terminal circulation of the parts, and the frequent want of rest, other contributing causes. The numerous and complicated synovial membranes mentioned above explain the extension of the disease. The calcaneus is the only bone in which mischief is likely to remain limited. The presence of an epiphysis to this bone appearing about the age of ten and joining at puberty is to be remembered as a starting-point of disease here. **Talipes.**—To take one instance, a case of talipes equino-varus, of congenital origin and confirmed degree, the following are the chief structural changes which should have been obviated and now have to be met, given briefly. *Calcaneus.*—This is elevated posteriorly, and rotated so that its long axis is directed obliquely inwards. *Talus (astragalus).*—The inclination of the neck inwards is much increased, and the whole bone protruded from the ankle-joint. According to some, the neck is increased in length. *Navicular.*—This is displaced inwards so that it articulates with the inner side of the head of the talus (astragalus), and its tuberosity may form a facet on the internal malleolus. *Cuboid.*—The dorsal surface of this is displaced downwards, and bears much of the pressure in walking. *Tendons.*—Those chiefly shortened are the tendo Achillis and those of the tibials and flexor digitorum longus. The tendo Achillis is displaced inwards. *Ligaments.*—Those on the outer side are stretched, those on the inner, especially the anterior part of the deltoid, the dorsal talo-navicular (superior astragalo-scaphoid) and the plantar calcaneo-navicular (inferior calcaneo-scaphoid) ligaments are shortened. The plantar fascia is also shortened, together with the abductor hallucis, which arises from it.

ARCHES OF THE FOOT

These are two—the **longitudinal** and the **transverse.**

(A) **Longitudinal arch** (figs. 1022, 1023, and 1024).—This is by far the most important. **Extent:** From the heel to the heads of the metatarsal bones. The toes do not add much to the strength and elasticity of the foot. (Humphry.) They enlarge its area and adapt it to inequalities of the ground, are useful in climbing, and in giving an impulse to the step before the foot is taken from the ground, in the third stage of walking. **Two pillars.**—The late Professor Humphry laid stress on the important differences between these two:—(1) **Posterior pillar:** This consists of the calcaneus and hinder part of the talus (astragalus), viz., only two bones in order to secure solidity, and to enable the calf-muscles to act directly upon the heel, without any of that loss of power which would be brought about by many moving joint-surfaces. (2) **Anterior pillar:** Here there are many bones and joints to provide (*a*) elastic springiness, and (*b*) width. This anterior pillar may again be divided into two: (*a*) An **inner pillar,** very elastic, consisting of the talus (astragalus), navicular, three cuneiforms, and three inner metatarsals. (*b*) An **outer,** formed by the cuboids and two outer metatarsals. This is stronger and less elastic, and tends to buttress up the inner pillar. **Keystone:** This is represented by the summit of the trochlear surface of the talus (astragalus). It differs from the keystones in ordinary arches in the following important particulars (Humphry): (*a*) in not being wedge-

FIG. 1023.—THE ARCH IN THE ORDINARY POSITION OF STANDING. (Ellis.)

shaped; (*b*) in not being so placed as to support and receive support from the two halves of the arch: in front the talus (astragalus) does fulfil this condition by fitting into the navicular; behind, it overlaps the calcaneus without at all supporting it; (*c*) this arch and the support of its keystone largely depend on ligaments and tendons; (*d*) it is a mobile keystone: to give it chances of shifting its pressure, and so obtaining rest, its equilibrium is not always maintained in one position.

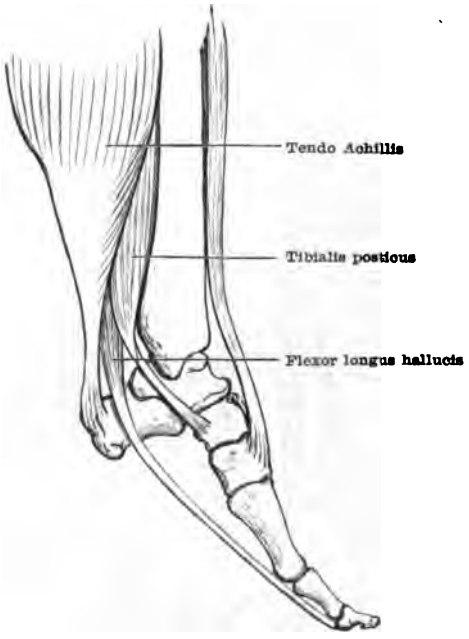
(B) **Transverse arch** (fig. 1020).—This is best marked about the centre of the foot, at the instep, along the tarso-metatarsal joints. This, as well as the longitudinal arch, yields in walking, and so gives elasticity and spring.

Uses of the arches.—(1) They give combined elasticity and strength to the tread. Thus they give firmness, free quickness, and dignity, both in standing and walking, instead of what we see in their absence, viz., the lameness of an artificial limb, and the shuffling or hobbling which goes with tight boots, deformed toes, flat-foot, bunions, corns, etc.; (2) they protect the plantar vessels, nerves, and muscles; (3) they add to man's height; (4) they make his gait a perfect combina-

tion of plantigrade and digitigrade, as is seen in man's walking, when he uses first the heel, then all the foot, and then the toes. (Humphry.)

Maintenance of the arch.—(1) **Plantar fascia.**—This is (*a*) a binding tie between the pillars of the longitudinal arch; (*b*) it protects the structures beneath; (*c*) it is a self-regulating ligament and protection. Thus, having a quantity of muscular tissue attached to its upper and back part, it constantly responds by the contraction of this, to the amount of any pressure made upon the foot. (2) **Plantar calcaneo-navicular ligament.**—This is a thick tie-plate of fibro-cartilaginous tissue, partly elastic, hence called the 'spring-ligament,' attached to the anterior margin of the sustentaculum tali and under surface of navicular. It is thickest at its inner side, where it blends with the anterior part of the deltoid ligament, and below, where the tibialis posterior, passing into the sole, is in contact with the ligament and gives much support to the head of the talus (astragalus) and the navicular, while it assists the power and spring of this ligament (*vide infra*). The dropping of the talus and navicular and their projection on the inner side in flat-foot are largely due to the giving way of the above ligament. (3) **Calcaneo-cuboid ligaments.** (*a*)

FIG. 1024.—THIS SHOWS THE EFFECT OF MUSCULAR ACTION IN THROWING UP THE ARCH. (Ellis.)



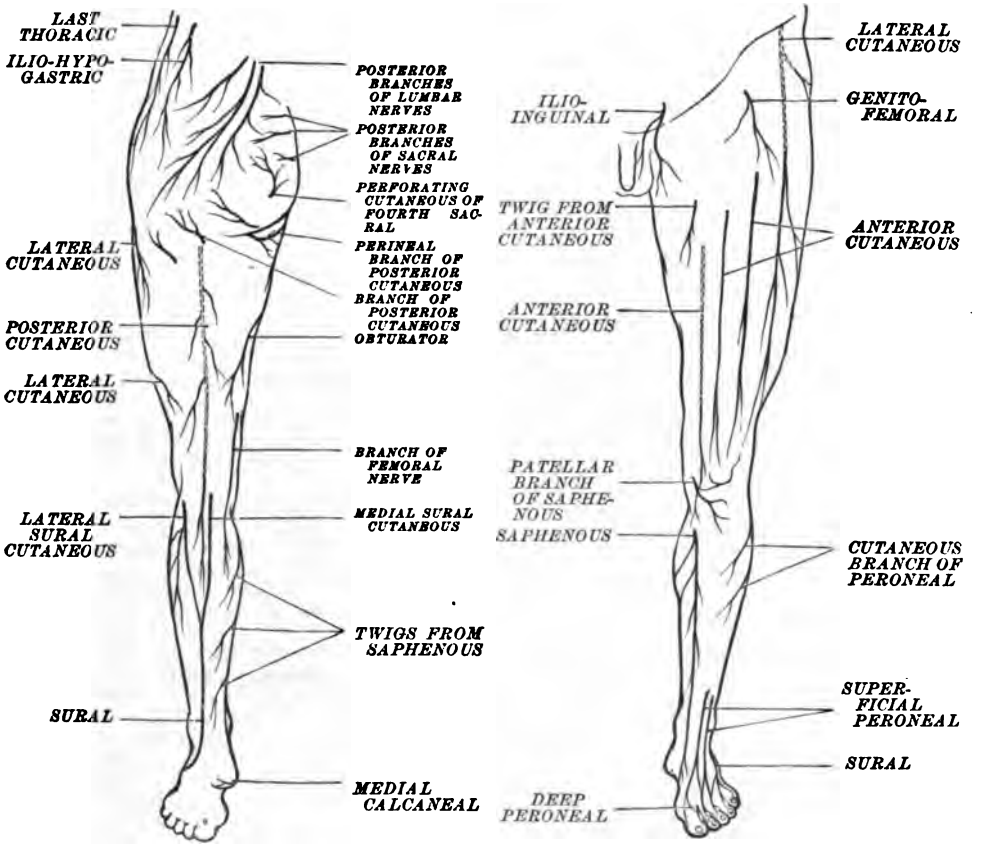
Long; (*b*) **short.**—These ligaments are the main support of the outer, firm, and less elastic part of the longitudinal arch. (4) **Tibialis posterior.**—The reason of this muscle having so many insertions below is to brace together the tarsal bones, and to prevent their separation when, in treading, the elastic anterior pillar tends to widen out. Of these numerous offsets, that to the navicular is the most important. Thus it strengthens the calcaneo-navicular ligament by blending with it, and thus supports the arch at a trying time. By coming into action when the heel is raised (fig. 1024), this tendon helps the calcaneo-navicular ligament to support the head of the talus, and to maintain the arch of the foot when the weight of the body is thrown forward on to the instep. In other words, the tibialis posterior comes into play just when the heaviest of its duties is devolving upon this ligament, viz., when the heel is being raised, and the body-weight is being thrown over the instep on to the opposite foot. (5) **Peroneus longus.**—This raises the outer pillar, and steadies the outer side of the arch. Further, by its strong process attached to the first metatarsal bone, it keeps the great toe strapped down firmly against the ground; thus, keeping down the anterior pillar of the longitudinal arch, it aids the firmness of the tread. (Humphry.) (6) **Tibialis anterior.**—This braces up the keystone of the arch. Thus, by keeping up the first (internal) cuneiform, it maintains the navicular, and so indirectly the talus (astragalus) *in situ*.

Fig. 1013 will remind the reader of the arrangement of the **superficial lymphatics of the lower extremity.**

These follow chiefly the saphenous veins, and enter the inguinal (p. 741) and popliteal nodes. The superficial lymphatics of the buttock enter the outer, and those over the adductor muscles the innermost, group of the inguinal glands.

The deep lymphatics of the lower limb, comparatively few in number, follow the course of the deeper vessels. After passing through some four or five glands deeply placed about the popliteal vessels (these glands also receive the lymphatics along the

FIG. 1025.—DISTRIBUTION OF CUTANEOUS NERVES ON THE POSTERIOR AND ANTERIOR ASPECTS OF THE INFERIOR EXTREMITY.



small saphenous vein), the lymph is carried up by lymphatics along the femoral artery to the deep femoral vessels; one very often occupies the femoral canal.

Fig. 1025 shows the distribution of the **superficial nerves** on both aspects of the limb.

Paralysis of the nerves of the lower extremity.—The student should take this opportunity of considering from the surgical anatomy the results of paralysis of the nerve chiefly affected, viz., the great sciatic and its branches. *Sciatic:* The limb hangs flail-like, much in the position of one affected with advanced infantile paralysis. In addition to the results of paralysis of its two divisions, flexion at the knee will be lost, owing to paralysis of the hamstrings. *Peroneal (external popliteal) nerve:* The extensors and peronei being paralysed the foot drops, it cannot be dorsiflexed at the ankle nor abducted at the medio-tarsal joint. Adduction at the latter joint is impaired owing to paralysis of the tibialis anterior. The arch of the foot is largely lost owing to paralysis of the peroneus longus. Slight extension of the two distal phalanges of the four outer toes is still possible by means of the interossei. Sensation is impaired over the distribution of the medial sural cutaneous (communicans peronei) deep, (anterior tibial), and superficial peroneal (musculo-cutaneous) nerves. *Tibial (internal popliteal) nerve:* Here the calf muscles, the flexors, and the muscles of the sole of the foot are paralysed. The ankle cannot be plantar-flexed.

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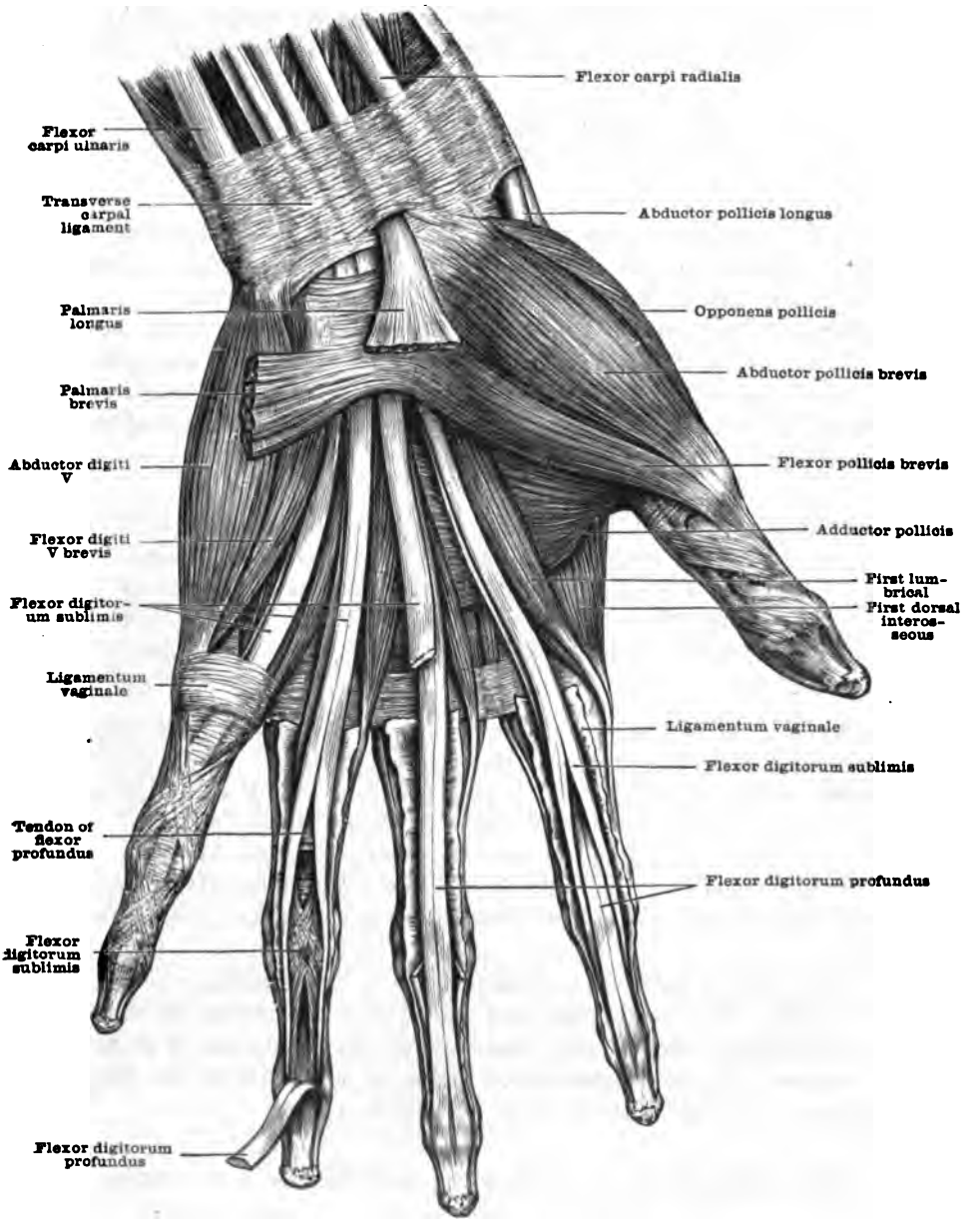

FIG. 336.—**THE SUPERFICIAL MUSCLES OF THE PALM OF THE HAND.**

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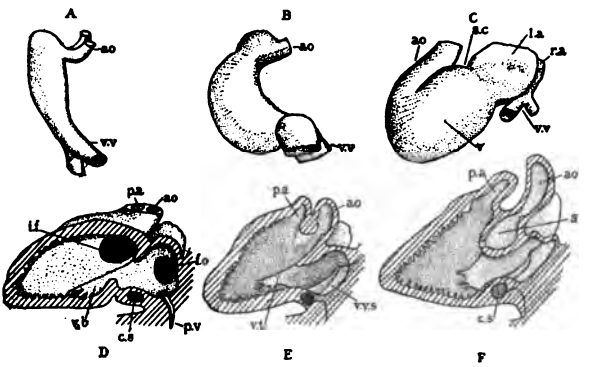

FIG. 159 (*Reduced*).—EMBRYONIC HEARTS.

A *and* B, *from Rabbits* 9 *days after coitus,* C, *from a human embryo of* 3 (?) *weeks;* D *and* E, *from a* 12 *mm. pig* (D *sectioned on the left of the median septum, and* E *on the right of it);* F, *from a* 13.6 *mm. human embryo, sectioned like* E.

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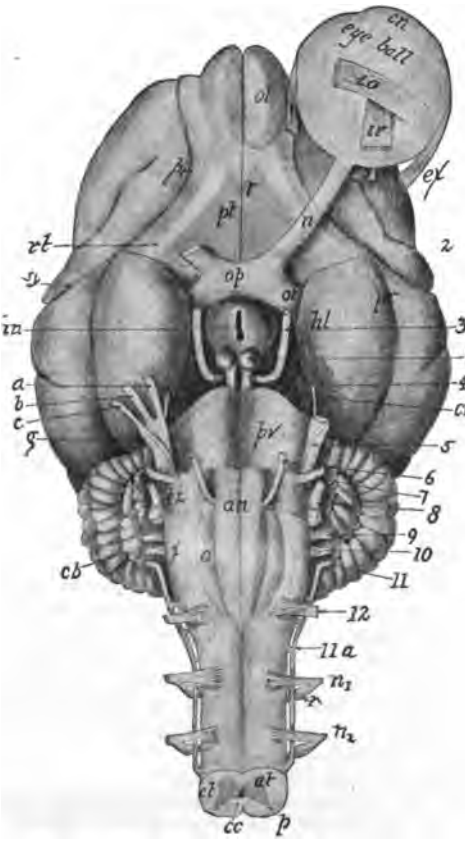

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